Symbiont ecology and its influence on the physiology and isotopic composition of a reef coral across space and time

CB Wall cbwall@hawaii.edu

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Contents

Project background

Sea level correction

```
#########################
# Sea level correction
#########################

#### attach data files
data<-read.csv("data/mastersheet_PanKBAY.csv") # master file
qPCR.Innis<-read.csv("data/PanKBay_summer_qPCR.csv") # qPCR from summer (Innis et al. 2018)

JuneTide=read.csv("data/environmental/sea level/Station_1612480_tide_ht_20160601-20160630.csv")
JulyTide=read.csv("data/environmental/sea level/Station_1612480_tide_ht_20160701-20160731.csv")
AugustTide=read.csv("data/environmental/sea level/Station_1612480_tide_ht_20160801-20160831.csv")
DecemberTide=read.csv("data/environmental/sea level/Station_1612480_tide_ht_20161201-20161222.csv")

Tide<-rbind(JuneTide, JulyTide, AugustTide, DecemberTide) # all MSL in meters

Tide$Time <- as.POSIXct(Tide$TimeUTC, format="%Y-%m-%d %H:%M:%S", tz="UTC")
attributes(Tide$Time)$tzone <- "Pacific/Honolulu"
# use attr(as.POSIXlt(Tide$Time),"tzone") to confirm in PST

Tide<-Tide[, c(-5:-8)] #remove unnecessary columns
```

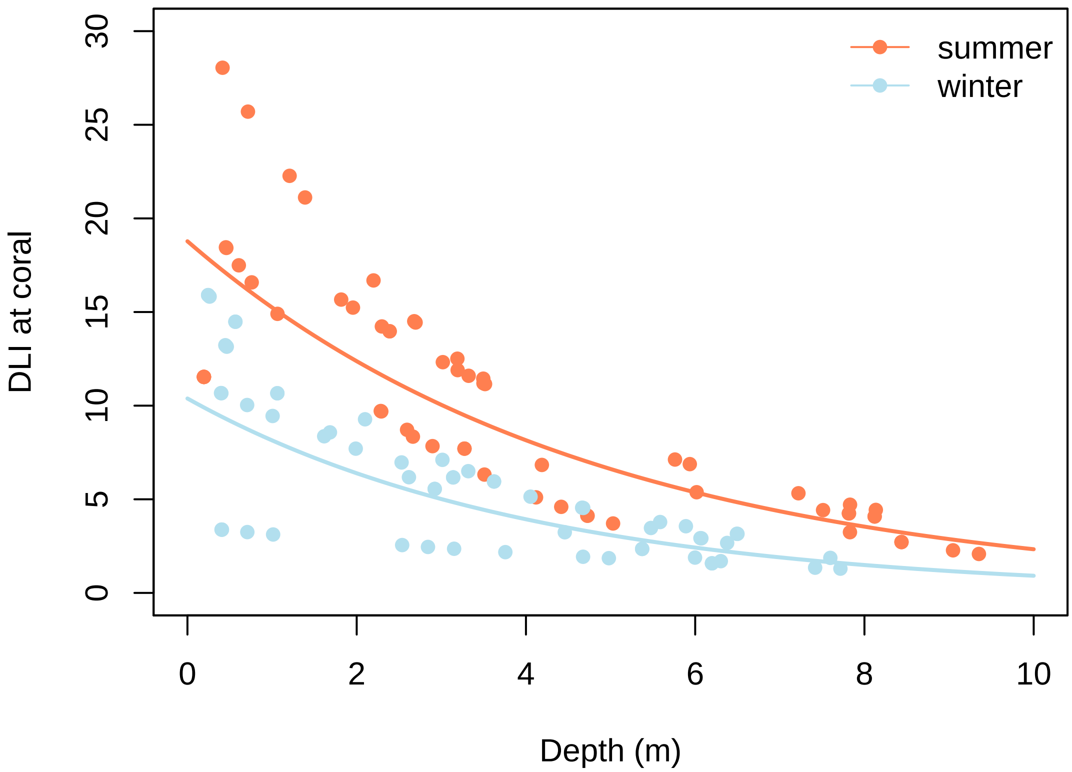
```
data$date.time<- as.POSIXct(paste(as.character(data$Date), as.character(data$Time.of.collection)),
                 format="%m/%d/%y %H:%M", tz="Pacific/Honolulu") # make sure time in HST for master

data$Time.r<-round_date(data$date.time,unit="6 minutes")
Tide$Time.r <- Tide$Time
data<-merge(data, Tide, by="Time.r", all.x=T)
data$newDepth <- data$Depth..m-data$TideHT # new depth in METERS
```

Light at Depth

```
######################### # LIGHT AT DEPTH
#############
######
# using new depth and the site-specific kd (light attenuation) determine approximate "light at depth" f

######

### attach necessary files
logger.depths<-read.csv("data/environmental/temp and light/light.logger.depths.csv") # depths for logge
kd.all<-read.csv("data/environmental/kd.all.csv") # kds for each site

# Seasonal DLI used for "period of collection" light levels
month.DLI<-read.csv("data/environmental/temp and light/Jun_DecPAR/All.DLI_long.csv")

# corals collected in June-July-August use summer time DLI for these months as indicator of average DLI
summer.DLI<-month.DLI[(month.DLI$Month=="June" | month.DLI$Month=="July" | month.DLI$Month=="August"),]
winter.DLI<-month.DLI[(month.DLI$Month=="November" | month.DLI$Month=="December" |month.DLI$Month=="Janu

# summer mean and SE dataframe
sum.mean<-aggregate(DLI~Site, summer.DLI, mean)
sum.SE<-aggregate(DLI~Site, summer.DLI, std.error)
sum.light.df<-cbind(sum.mean, sum.SE[2])
colnames(sum.light.df)=c("Site", "mean.DLI", "SE")
sum.light.df$Season<-as.factor("summer")

# winter mean and SE dataframe
wint.mean<-aggregate(DLI~Site, winter.DLI, mean)
wint.SE<-aggregate(DLI~Site, winter.DLI, std.error)
wint.light.df<-cbind(wint.mean, wint.SE[2])
colnames(wint.light.df)=c("Site", "mean.DLI", "SE")
wint.light.df$Season<-as.factor("winter")

season.DLI<-rbind(sum.light.df[,c(4,1,2:3)], wint.light.df[,c(4,1,2:3)]) # compiled means for DLI at ~2

write.csv(season.DLI, "data/environmental/season.DLI.csv")
########################################
### make new dataframe for calculations
df.light<- data[, c("Season", "Location", "newDepth")]

# make a column of "depth differences" relative to where ~2m logger was deployed
df.light$depth.diff<-ifelse(df.light$Location=="F1-R46", df.light$newDepth-1.8288,
                        ifelse(df.light$Location=="F8-R10", df.light$newDepth-1.8288,
```

```
                                        ifelse(df.light$Location=="HIMB", df.light$newDepth-1.8288,
                                               df.light$newDepth-2.4384))) # last statement for remaining site

# make a column for sample-specific light at depth (estimate) based on kd
# follow: #with 2m as baseline#  E(depth) = E(2m)*exp(-k_d*(depth - 2m))
# so that:     light at depth = DLI at mid.depth * exp (-kd *(delta shallow-deep in m))


df.light$Light<-ifelse(df.light$Location=="HIMB" & df.light$Season=="summer",
                         season.DLI$mean.DLI[1]*exp(-kd.all$kd[1]*df.light$depth.diff), # summer HIMB
                  ifelse(df.light$Location=="F8-R10" & df.light$Season=="summer",
                         season.DLI$mean.DLI[2]*exp(-kd.all$kd[2]*df.light$depth.diff), # summer R10
                  ifelse(df.light$Location=="R42" & df.light$Season=="summer",
                         season.DLI$mean.DLI[3]*exp(-kd.all$kd[3]*df.light$depth.diff), # summer R42
                  ifelse(df.light$Location=="F1-R46" & df.light$Season=="summer",
                                season.DLI$mean.DLI[4]*exp(-kd.all$kd[4]*df.light$depth.diff), # summe

                  ifelse(df.light$Location=="HIMB" & df.light$Season=="winter",
                         season.DLI$mean.DLI[5]*exp(-kd.all$kd[1]*df.light$depth.diff), # winter HIMB
                  ifelse(df.light$Location=="F8-R10" & df.light$Season=="winter",
                         season.DLI$mean.DLI[6]*exp(-kd.all$kd[2]*df.light$depth.diff), # winter R10
                  ifelse(df.light$Location=="R42" & df.light$Season=="winter",
                         season.DLI$mean.DLI[7]*exp(-kd.all$kd[3]*df.light$depth.diff), # winter R42
                         season.DLI$mean.DLI[8]*exp(-kd.all$kd[4]*df.light$depth.diff)) # winter R46
                           ))))))

###### plot of light x depth by season
df.light$Location <- factor(df.light$Location, levels = c("F1-R46", "R42", "F8-R10", "HIMB"))

plot.by.sites=ggplot(df.light, aes(Light)) + geom_density(aes(fill=Location), alpha=0.3, position = 'sta

plot.by.site=ggplot(df.light, aes(Light)) + geom_density(aes(fill=Season), alpha=0.3, position = 'stack
  scale_x_continuous(limits=c(0, 40)) + ggtitle("Light at Depth by Seasons") + facet_wrap(~Location, sca

######
# can loop as a list
p=ggplot(df.light, aes(Light, fill=Season)) + geom_density(alpha=0.3, position = 'stack') + scale_x_con

plots=dlply(df.light, .(Location), function(x) p %+% x + facet_wrap(~Location))


###### plot of light x depth by season with exponential curve fitting
Sum<-df.light[(df.light$Season=="summer"),]
Win<-df.light[(df.light$Season=="winter"),]

plot(Light~newDepth, Sum, col="coral", pch=16, xlab="Depth (m)", ylab="DLI at coral",
     ylim=c(0, 30), xlim=c(0, 10))
summod<-lm(log(Light)~newDepth, Sum)
curve(exp(coef(summod)["(Intercept)"]+coef(summod)["newDepth"]*x), add=TRUE, col="coral", lwd=2)
par(new=T)
plot(Light~newDepth, Win, col="lightblue2", pch=16, xaxt="n", yaxt="n",
     xlab="", ylab="", ylim=c(0, 30), xlim=c(0, 10))
wintmod<-lm(log(Light)~newDepth, Win)
```

```r
curve(exp(coef(wintmod)["(Intercept)"]+coef(wintmod)["newDepth"]*x), add=TRUE, col="lightblue2", lwd=2)
legend("topright", legend=c("summer", "winter"), col=c("coral", "lightblue2"), lty=1, lwd=1, pch=16, bt
```



Isotopes in particulates

Plankton tows and seawater collections to parameterized particulates and plankters as potential heterotrophic end members available to reef corals. Sampling was done at 4 sites where corals were collected [*North*: (Reef 42, fringe-Reef 46), and *South*: (HIMB, fringe-Reef 10)], as well as two reefs in central region of the bay where corals were not collected (*Central*: Reef 25, fringe-Reef 25) to increase spatial resolution of suspended particulate isotope sample sizes. Using size-fractioned materials collected in seawater and plankton tows, we examined the spatial (*among reef sites*) and temporal patterns (*among seasons*) in stable isotope values of size-fractioned end members. Carbon and nitrogen isotope values among the 6 reef sites were not significantly different ($p > 0.140$), season had marginal effects ($p > 0.049$), whereas fraction influenced isotope values significantly ($p < 0.001$). Therefore, isotope values were pooled among reefs and seasons to best interpret size-fraction isotope values.

```r
SWiso<-read.csv("data/isotopes_SW_all times.csv")

anova(lm(d13C~Reef.ID+Time.point+SW.fraction..um, data=SWiso)) # no site effect
```

```
## Analysis of Variance Table
##
## Response: d13C
##                 Df  Sum Sq Mean Sq F value    Pr(>F)
## Reef.ID          5  17.926  3.5852  1.3418 0.2626013
## Time.point       1   7.921  7.9207  2.9645 0.0914188 .
## SW.fraction..um  4  76.419 19.1048  7.1504 0.0001286 ***
## Residuals       49 130.920  2.6718
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(lm(d15N~Reef.ID+Time.point+SW.fraction..um, data=SWiso)) # no site effect
```

```
## Analysis of Variance Table
##
## Response: d15N
##                 Df  Sum Sq Mean Sq F value    Pr(>F)
## Reef.ID          5  2.3255  0.4651  1.7291   0.14557
## Time.point       1  1.0935  1.0935  4.0653   0.04927 *
## SW.fraction..um  4 30.3773  7.5943 28.2335 3.454e-12 ***
## Residuals       49 13.1802  0.2690
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
SWiso$Reef.ID<-factor(SWiso$Reef.ID, levels=c("F1-46", "R42", "F2-R25", "R25", "F8-R10", "HIMB"))
SWiso$SW.fraction..um<-factor(SWiso$SW.fraction..um, levels=c(">243", "<243", "100-243", "10-100", "0-1

winter.data<-SWiso[(SWiso$Time.point=="winter"),]
summer.data<-SWiso[(SWiso$Time.point=="summer"),]
```

```r
# plots of SW isotopes by Season-- first showing by size, then by site
op<-par(mfrow = c(2,2), mar=c(5,5,2,1))

######### Sizes
# Summer size d13C
plot(d13C~SW.fraction..um, data=summer.data, ylim=c(-25,-10),
     main=expression(paste("summer"~ delta^{13}, "C")), ylab=expression(paste(delta^{13}, "C (%, V-PDB)
     col="paleturquoise3", cex.axis=0.7, cex.main=1, cex.lab= 0.8, xlab=expression(paste("Size Fraction

# Winter size d13C
plot(d13C~SW.fraction..um, data=winter.data, ylim=c(-25,-10),
     main=expression(paste("winter"~ delta^{13}, "C")), ylab=expression(paste(delta^{13}, "C (%, V-PDB)
     col="paleturquoise3", cex.axis=0.7, cex.main=1, cex.lab= 0.8, xlab=expression(paste("Size Fraction

# Summer size d15N
plot(d15N~SW.fraction..um, data=summer.data, ylim=c(3,10),
     main=expression(paste("summer"~ delta^{15}, "N")), col="plum", cex.axis=0.7, cex.main=1, cex.lab= 0
     xlab=expression(paste("Size Fraction (", mu,m,")")),
     ylab=expression(paste(delta^{15}, "N (%, air)")))

# Winter size d15N
plot(d15N~SW.fraction..um, data=winter.data, ylim=c(3,10),
     main=expression(paste("winter"~ delta^{15}, "N")), ylab=expression(paste(delta^{15}, "N (%, air)")
     col="plum", cex.axis=0.7, cex.main=1, cex.lab= 0.8, xlab=expression(paste("Size Fraction (", mu,m,
```

```r
######## Sites
op<-par(mfrow = c(2,2), mar=c(5,5,2,1))

# Summer site d13C
plot(d13C~Reef.ID, data=summer.data, ylim=c(-25,-10),
     main=expression(paste("summer"~ delta^{13}, "C")), ylab=expression(paste(delta^{13}, "C (%, V-PDB)
     col="lightskyblue", cex.axis=0.7, cex.main=1, cex.lab= 0.8, xlab="Reef Sites")

# Winter site d13C
plot(d13C~Reef.ID, data=winter.data, ylim=c(-25,-10),
```

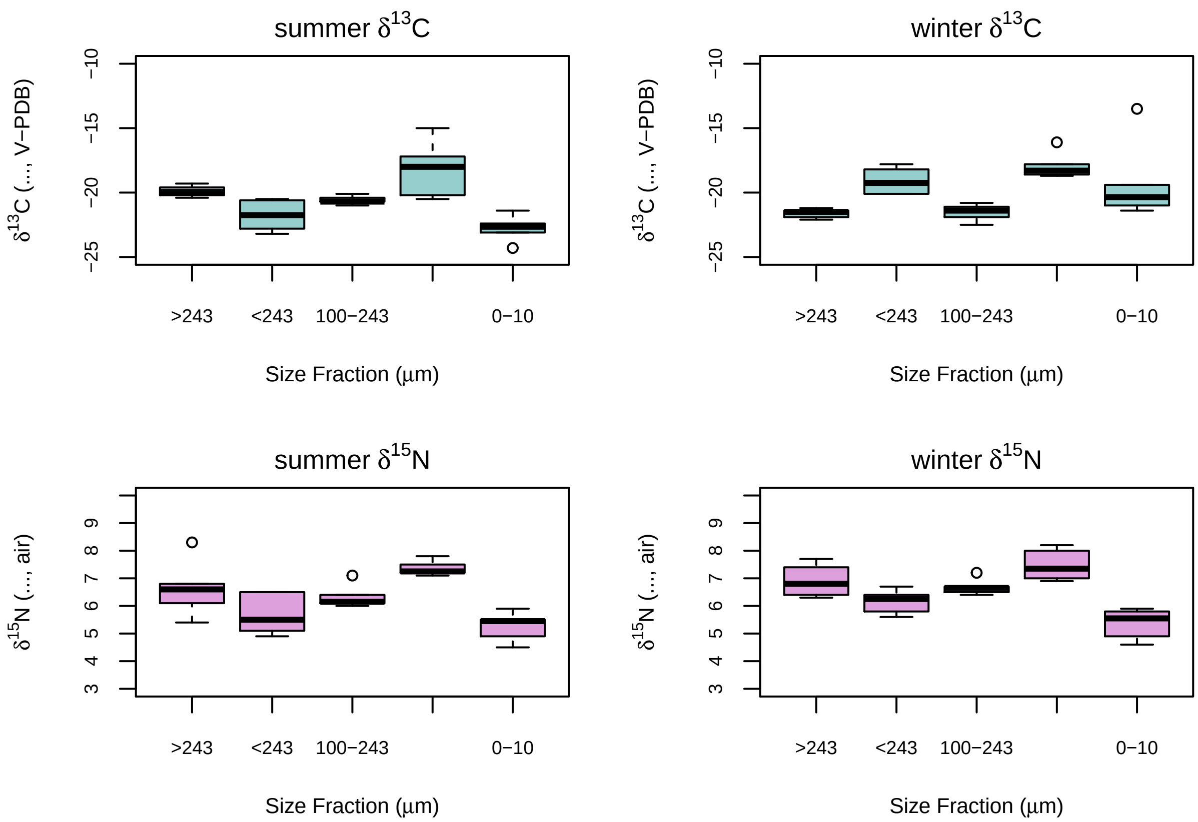


Figure 1: *Figures of size-fractioned sample isotope values stratified by seasons (summer and winter)*

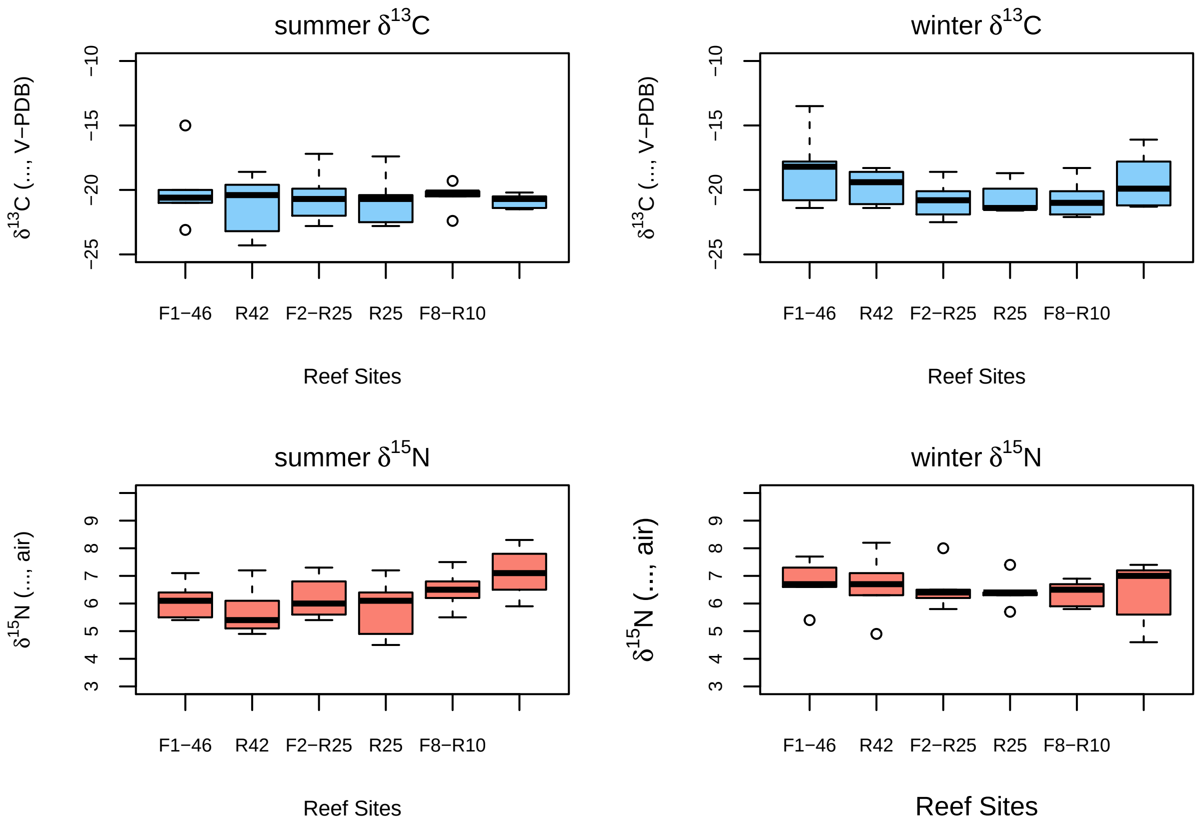


Figure 2: *Figures of isotope values in seawater particles stratified by sites (northwest to southeast)*

```
     main=expression(paste("winter"~ delta^{13}, "C")), ylab=expression(paste(delta^{13}, "C (‰, V-PDB)
     col="lightskyblue", cex.axis=0.7, cex.main=1, cex.lab= 0.8, xlab="Reef Sites")

# Summer site d15N
plot(d15N~Reef.ID, data=summer.data, ylim=c(3,10),
     main=expression(paste("summer"~ delta^{15}, "N")), col="salmon", cex.axis=0.7, cex.main=1, cex.lab
     ylab=expression(paste(delta^{15}, "N (‰, air)")), xlab="Reef Sites")

# Winter site d15N
plot(d15N~Reef.ID, data=winter.data, ylim=c(3,10),
     main=expression(paste("winter"~ delta^{15}, "N")), ylab=expression(paste(delta^{15}, "N (‰, air)"))
     col="salmon", cex.axis=0.7, cex.main=1, xlab="Reef Sites")
```

```
####
#### making scatter for d15N and d13C, pooled across seasons and sites
mix.N.mean<-aggregate(d15N~SW.fraction..um, data=SWiso, mean)
mix.N.SE<-aggregate(d15N~SW.fraction..um, data=SWiso, std.error)
mix.C.mean<-aggregate(d13C~SW.fraction..um, data=SWiso, mean)
mix.C.SE<-aggregate(d13C~SW.fraction..um, data=SWiso, std.error)
mix.data<-cbind(mix.N.mean, mix.C.mean[c(2,0)], mix.N.SE[c(2,0)], mix.C.SE[c(2,0)]); colnames(mix.data)

colors=c("#FF6A6A", "#00B2EE", "#FFB90F", "#3CB371", "#8B7500")
op<-par(mfrow = c(1,1), mar=c(5,4,1,5),xpd=TRUE, pty="sq")
```

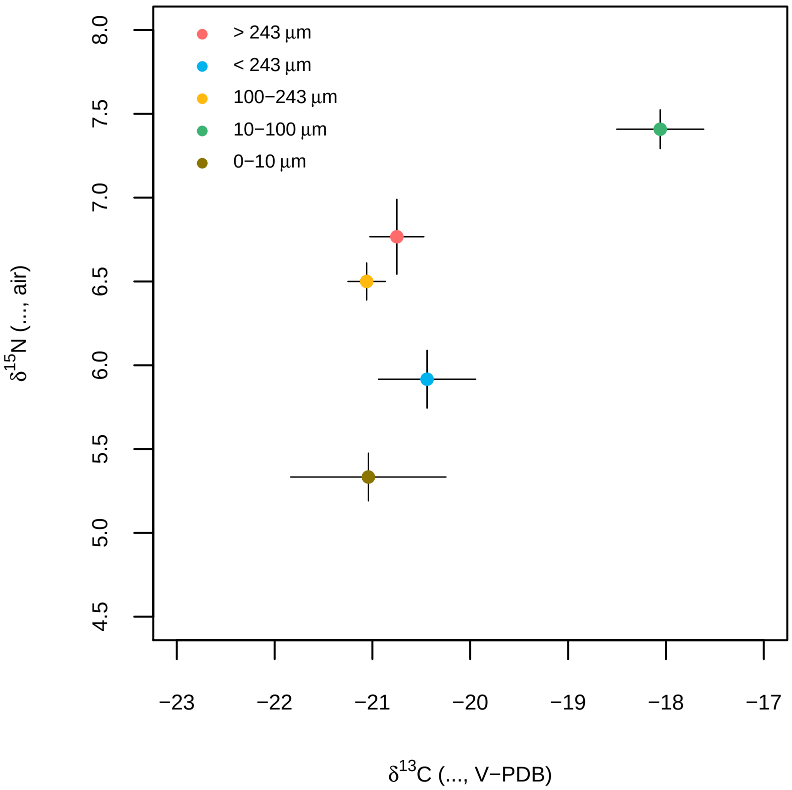


Figure 3: *Isotope values for size-fractioned seawater particles and plankters pooled across 2 seasons and 6 reef sites*

```
size.labels=c(expression(paste("> 243"~mu,m)), expression(paste("< 243"~mu,m)), expression(paste("100-24

#### make the plot
plot(d15N~d13C, data=mix.data, type="n", ylim=c(4.5,8), xlim=c(-23,-17), tck=-0.03, cex.axis=0.7, cex.la
     ylab=expression(paste(delta^{15}, "N (‰, air)")), xlab=expression(paste(delta^{13}, "C (‰, V-PDB)")
legend("topleft", inset=c(0.05,0.0), legend=size.labels, col=colors, pch=19, cex=0.6, bty="n", x.intersp
arrows(mix.data$d13C-mix.data$d13C.SE, mix.data$d15N, mix.data$d13C+mix.data$d13C.SE, mix.data$d15N, len
arrows(mix.data$d13C, mix.data$d15N-mix.data$d15N.SE, mix.data$d13C, mix.data$d15N+mix.data$d15N.SE, len
points(d15N~d13C, data=mix.data, pch=19, cex=0.8, col=colors)
```

```
dev.copy(pdf, "output/iso.sources.KBay.pdf", encod="MacRoman", height=4, width=4)
dev.off()
```

Biology

```
################################
### Biological responses
################################

#data : this is the master file

# add in light at depth column from df.light dataframe
data$Light<-df.light$Light
```

```
##### produce a categorical depth bin ####
depth<-data$newDepth
data$depth.bin<-factor(ifelse(depth<2, "<2m", ifelse(depth >2 & depth <4, "2-4m", ifelse(depth >4 & dep

aggregate(Sample.ID~depth.bin+Season+Location, data, length)
data$depth.bin.small<-factor(ifelse(depth<4, "<4m", ">4m"), levels= c("<4m", ">4m"))

################################################
# calculate, normalized dependent variables
################################################
str(data)
data$cells.ml<-as.numeric(data$cells.ml)

# helpful shorthand
SA<-data$surface.area # surface area in cm2
blastate<-data$total.blastate.ml # tissue slurry blastate in ml

# AFDW.mg. == convert AFDW g to mg, mutiply by blastate volume, divide by cm2
data$biomass<- (data$mg.biomass.ml*blastate)/SA

# Symbiodinium.cells. == cell.ml * blastate / SA
data$zoox<- (data$cells.ml*blastate)/SA

# total chlorophyll == ug.chl.a.ml * blastate + ug.chl.c2.ml * blastate / SA
data$chltot<-(data$ug.chl.a.ml)+(data$ug.chl.c2.ml)*blastate/SA

# pg.chlorophyll.a..cell + pg.chlorophyll.c2..cell == ug.chltot.ml * 10^6 / cells.ml
data$chlcell<- (data$ug.chl.a.ml*10^6+data$ug.chl.c2.ml*10^6)/data$cells.ml
```

qPCR

```
####################
# qPCR
#########

# qPCR
# Use steponeR to import data and calculate proporation of C and D symbionts
source_url("https://raw.githubusercontent.com/jrcunning/steponeR/master/steponeR.R")
Mcap.plates <- list.files(path="data/qPCR", pattern = "txt$", full.names = T); Mcap.plates
Mcap <- steponeR(files=Mcap.plates, delim="\t",
                 target.ratios=c("C.D"),
                 fluor.norm=list(C=2.26827, D=0),
                 copy.number=list(C=33, D=3),
                 ploidy=list(C=1, D=1),
                 extract=list(C=0.813, D=0.813))

Mcap <- Mcap$result
head(Mcap)

# remove +/-control
Mcap <- Mcap[grep("+C52", Mcap$Sample.Name, fixed=T, invert = T), ]
Mcap <- Mcap[grep("H2O", Mcap$Sample.Name, fixed=T, invert = T), ]
```

```r
# to remove any early-amplification CT noise
Mcap$C.CT.mean[which(Mcap$C.CT.mean < 15)] <- 0

#Remove failed samples, i.e., those where either C or D were NOT found in both reps
Mcap$fail <- ifelse(Mcap$C.reps < 2 & Mcap$D.reps < 2, TRUE, FALSE)
fails <- Mcap[Mcap$fail==TRUE, ]
Mcap <- Mcap[which(Mcap$fail==FALSE),]

# replace CT means with 'NA' as zero
Mcap$C.CT.mean[is.na(Mcap$C.CT.mean)] <-0
Mcap$D.CT.mean[is.na(Mcap$D.CT.mean)] <-0

Mcap$C.D[is.na(Mcap$C.D)] <- 1 # sets all infinity (= 100% C) to 1.0

# caluclate proportion C and proprtion D where C and D are both present
Mcap$propC<- Mcap$C.D / (Mcap$C.D + 1)
Mcap$propD<- 1 / (Mcap$C.D + 1)

# where C and D are not cooccuring...
# if C.D = 1 = 100% C, make 'PropC' = 1 and 'PropD' = 0
# if C.D = 0 = 100% D, make 'PropD' = 1 and 'PropC' = 0
Mcap$propC[which(Mcap$C.D==1)] <- 1
Mcap$propD[which(Mcap$propC==1)] <- 0
Mcap$propD[which(Mcap$C.D==0)] <- 1

# calculate FOUR COMMUNITY categories: C, C>D, D>C, D
Mcap$Mix <- factor(ifelse(Mcap$propC > Mcap$propD, ifelse(Mcap$propD!= 0, "CD", "C"), ifelse(Mcap$propD

# Identify SINGLE dominant symbiont clade: C or D
Mcap$Dom <- factor(substr(as.character(Mcap$Mix), 1, 1))

# Set zeros to NA to facilitate log transformation
Mcap$propC[which(Mcap$propC==0)] <- NA
Mcap$propD[which(Mcap$propD==0)] <- NA

######## look for duplicates in dataset by year and type of event (bleach/recover)
Mcap[duplicated(Mcap$Sample.Name), ] ## duplicates

# remove duplicated
Mcap<-Mcap[!(Mcap$Sample.Name=="HIMB_15" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R10_05" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R42_06" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R46_01" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R46_02" & Mcap$File.Name=="Wall_PanKbay_plate2.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R46_03" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="HIMB_13" & Mcap$File.Name=="Wall_PanKbay_plate2.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="HIMB_14" & Mcap$File.Name=="Wall_PanKbay_plate2.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R10_15" & Mcap$File.Name=="Wall_PanKbay_plate3.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R10_15" & Mcap$File.Name=="Wall_PanKbay_plate1.txt"),]
Mcap<-Mcap[!(Mcap$Sample.Name=="R42_11" & Mcap$File.Name=="Wall_PanKbay_plate2.txt"),]

# parse Sample ID and Site from "Site.Name"
Mcap<-cbind(Mcap, colsplit(Mcap$Sample.Name, pattern= "_", c("Location", "Sample.ID")))
```

```r
Mcap$Season<-as.factor("winter")
Mcap$Location<-as.factor(Mcap$Location)

Mcap$Location<-revalue(Mcap$Location, c("R10"="F8-R10", "R46"="F1-R46")) # rename factor levels

# make new factors for bay region and reef type
Mcap$Bay.region <- ifelse(Mcap$Location=="R42" | Mcap$Location=="F1-R46", "northern", "southern")
Mcap$Reef.type <- ifelse(Mcap$Location=="R42" | Mcap$Location=="HIMB", "patch", "fringe")

### reorder columns and finish
Mcap<-Mcap[, c(17,15,19,18,16, 1:14)] # reordered to match masterdata, and finish

### structure winter and summer qPCR dataframes to have same columns and combine dataframe
qPCR.winter<-Mcap[ , (names(Mcap) %in%
            c("Season", "Location", "Reef.type", "Bay.region", "Sample.ID", "propC", "propD", "Mix", "Do
qPCR.summer<-qPCR.Innis[ , (names(qPCR.Innis) %in%
            c("Season", "Location", "Reef.type", "Bay.region", "Sample.ID", "propC", "propD", "Mix", "Do

# merge qPCR files
qPCR.all<-rbind(qPCR.winter, qPCR.summer)

# add to master data
data.all<-merge(data, qPCR.all, by=c("Season", "Location", "Reef.type", "Bay.region", "Sample.ID"), all

###### remove columns no longer needed, update "Depth" to be tide-corrected depth )= newDepth
data.trim<-data.all[ , !(names(data.all) %in% c("total.blastate.ml", "Date", "Time.of.collection", "Dept

data.trim$symb..C.N[data.trim$symb..C.N>=12.520270]=NA # set this outlier to NA
```

Models

physiology

Total Biomass

```r
########## ##########
######### biomass ----
Y<-model.data$biomass
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
summary(full)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season * Light * Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 805.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.4430 -0.6942 -0.0371  0.5787  2.9820
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
```

```
##  Location (Intercept)  8.222   2.867
##  Residual             56.407   7.510
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                          Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)               28.7724     2.6187  19.3400  10.987 9.27e-10 ***
## Seasonwinter              -7.6360     2.9066 108.3200  -2.627  0.00986 **
## Light                     -0.3483     0.2189 109.3900  -1.592  0.11437
## DomD                     -11.6171     6.6078 109.7400  -1.758  0.08152 .
## Seasonwinter:Light         1.0487     0.3636 109.6400   2.884  0.00473 **
## Seasonwinter:DomD         17.2336     7.9247 109.3400   2.175  0.03181 *
## Light:DomD                 0.9354     0.4399 109.2600   2.126  0.03574 *
## Seasonwinter:Light:DomD  -1.2701     0.6885 109.2600  -1.845  0.06779 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light  DomD   Ssnw:L Ssn:DD Lgh:DD
## Seasonwintr -0.613
## Light       -0.719  0.622
## DomD        -0.254  0.258  0.252
## Ssnwntr:Lgh  0.406 -0.803 -0.565 -0.198
## Ssnwntr:DmD  0.209 -0.373 -0.206 -0.832  0.311
## Light:DomD   0.335 -0.324 -0.466 -0.919  0.318  0.763
## Ssnwnt:L:DD -0.208  0.425  0.290  0.594 -0.533 -0.857 -0.643
```

```
print(anova(full, type=2), digits=4)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##                   Sum Sq Mean Sq NumDF DenDF F.value Pr(>F)
## Season            215.45  215.45     1 108.2   3.820 0.0532 .
## Light              53.34   53.34     1 109.8   0.946 0.3330
## Dom                 0.30    0.30     1 109.4   0.005 0.9421
## Season:Light      289.47  289.47     1 109.2   5.132 0.0255 *
## Season:Dom        266.76  266.76     1 109.3   4.729 0.0318 *
## Light:Dom          86.12   86.12     1 108.8   1.527 0.2192
## Season:Light:Dom 191.95  191.95     1 109.3   3.403 0.0678 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ranef(full)
```

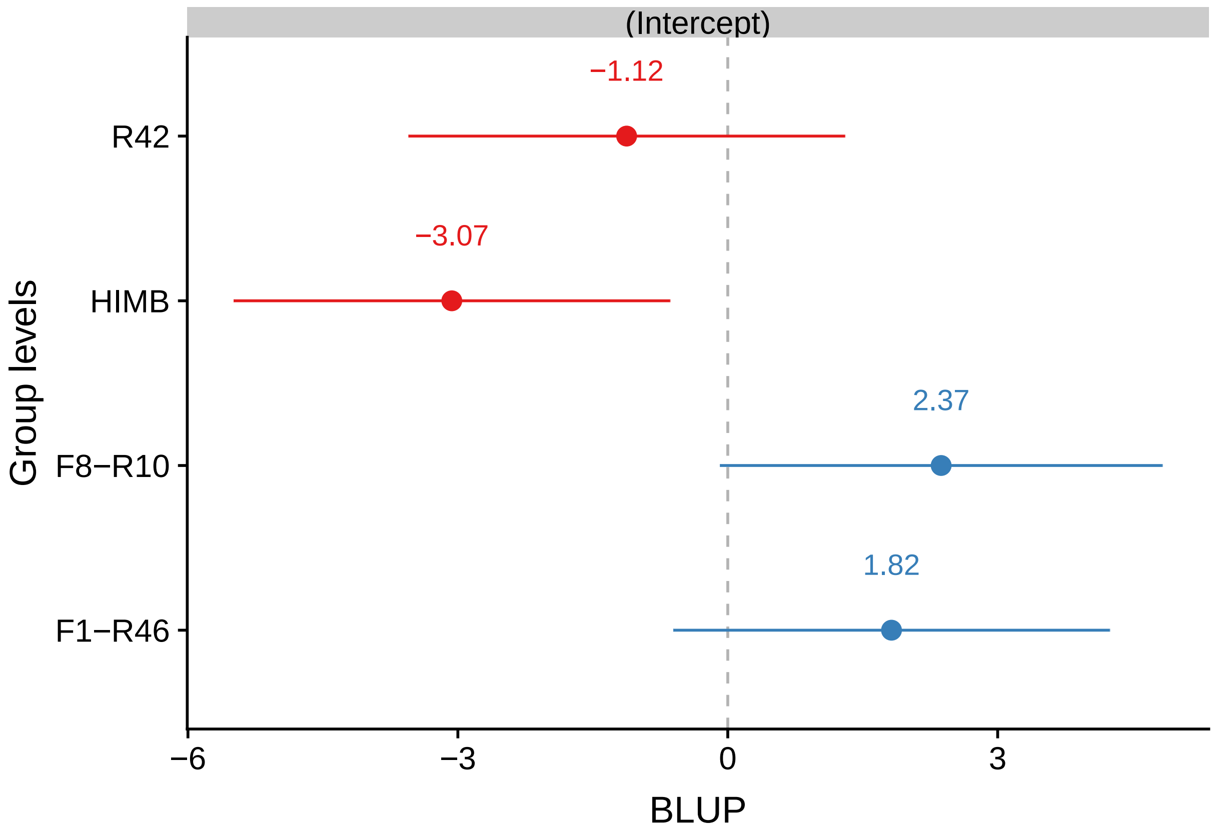
```
## $Location
##        (Intercept)
## F1-R46    1.819827
## F8-R10    2.371571
## HIMB     -3.067216
## R42      -1.124182
```

```
fixef(full)
```

```
##             (Intercept)            Seasonwinter                   Light
##              28.7724070              -7.6359780              -0.3483208
##                    DomD      Seasonwinter:Light       Seasonwinter:DomD
```

```
##              -11.6171087               1.0487075               17.2336137
##               Light:DomD Seasonwinter:Light:DomD
##                0.9353690              -1.2700733
```

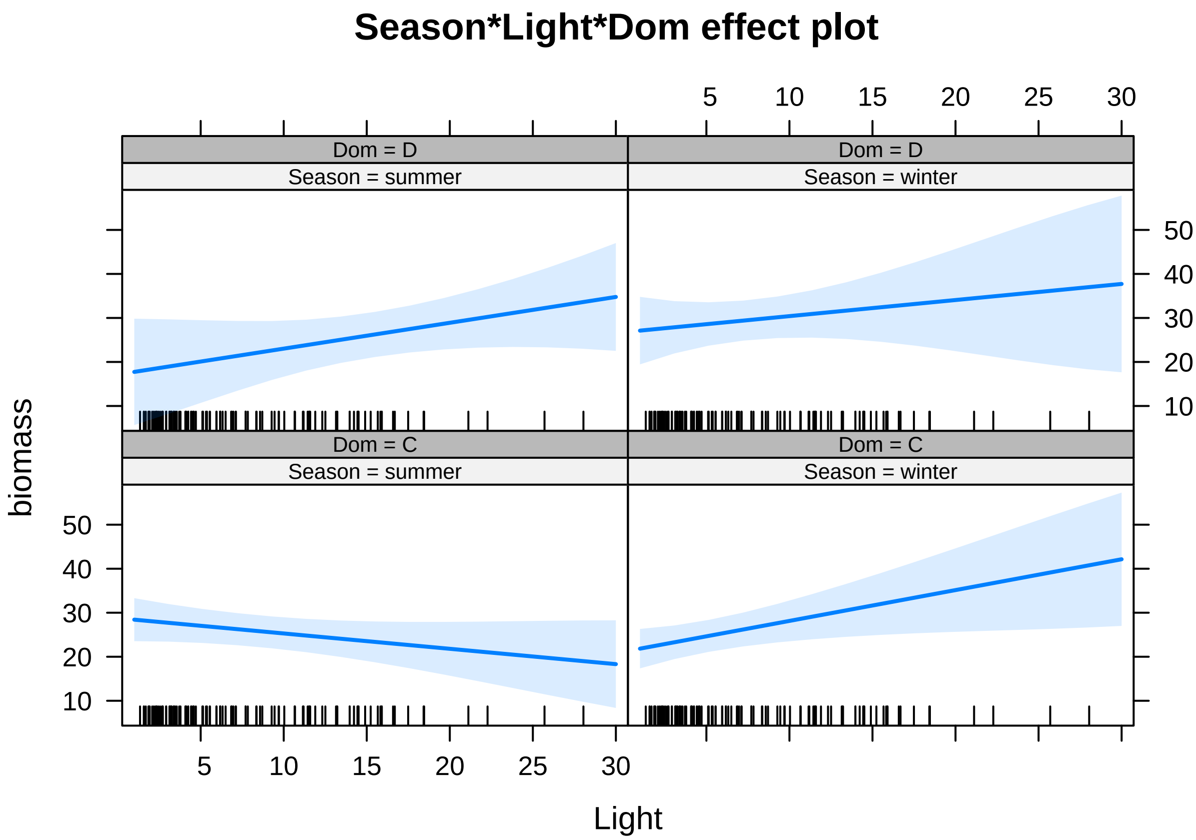
```r
sjp.lmer(full, y.offset = .4)
```




```r
#sjp.lmer(full, vars = "Seasonwinter", type = "ri.slope")

posthoc<-emmeans(full, ~Light:Season)
CLD(posthoc, Letters=letters)
```

```
##     Light Season   emmean       SE    df lower.CL upper.CL .group
##  8.238607 summer 23.94724 2.302325 11.73 18.91804 28.97644  a
##  8.238607 winter 28.33614 1.844474  5.11 23.62535 33.04693   b
##
## Results are averaged over the levels of: Dom
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## significance level used: alpha = 0.05
```

```r
plot(allEffects(full), ylab="biomass", par.strip.text=list(cex=0.7))
```



Chlorophyll a

```r
######### chltotal--
Y<-model.data$chltot
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
summary(full)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season * Light * Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 417.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.26787 -0.64400 -0.09381  0.53088  3.12573
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.3246   0.5697
##  Residual             1.7029   1.3050
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                           Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)                5.42443    0.47567  14.97000  11.404 8.82e-09
## Seasonwinter               2.64741    0.50510 108.18000   5.241 7.95e-07
```

```
## Light                    -0.04057    0.03805 109.10000  -1.066  0.28869
## DomD                      1.02243    1.14922 109.42000   0.890  0.37559
## Seasonwinter:Light       -0.14846    0.06324 109.33000  -2.348  0.02070
## Seasonwinter:DomD        -3.81872    1.37790 109.06000  -2.771  0.00656
## Light:DomD               -0.12052    0.07649 108.99000  -1.576  0.11799
## Seasonwinter:Light:DomD   0.27682    0.11971 108.98000   2.313  0.02263
##
## (Intercept)             ***
## Seasonwinter            ***
## Light
## DomD
## Seasonwinter:Light      *
## Seasonwinter:DomD       **
## Light:DomD
## Seasonwinter:Light:DomD *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light  DomD   Ssnw:L Ssn:DD Lgh:DD
## Seasonwintr -0.586
## Light       -0.688  0.621
## DomD        -0.242  0.258  0.250
## Ssnwntr:Lgh  0.388 -0.803 -0.563 -0.200
## Ssnwntr:DmD  0.199 -0.374 -0.205 -0.832  0.312
## Light:DomD   0.320 -0.325 -0.464 -0.919  0.319  0.763
## Ssnwnt:L:DD -0.198  0.425  0.288  0.594 -0.533 -0.857 -0.644
```

```
print(anova(full, type=2), digits=4)
```

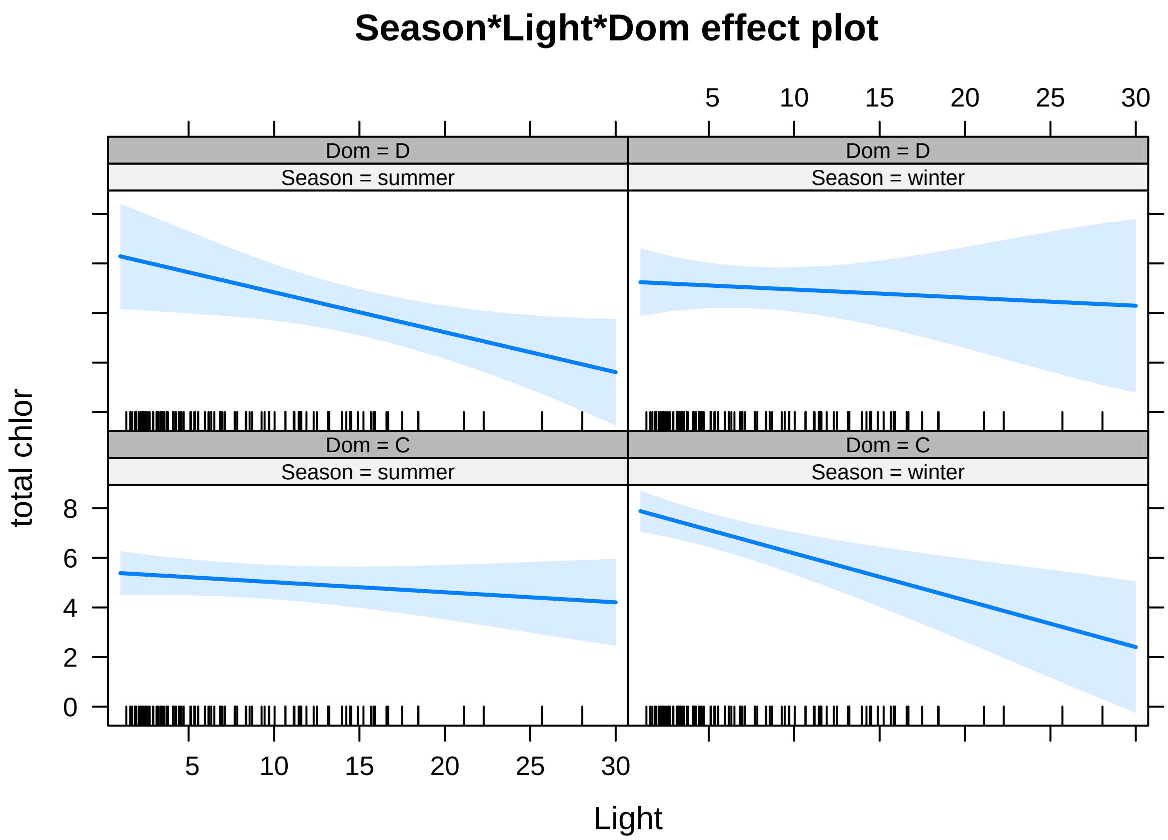
```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##                  Sum Sq Mean Sq NumDF DenDF F.value   Pr(>F)
## Season            34.97   34.97     1 108.0  20.533 1.52e-05 ***
## Light             20.83   20.83     1 110.7  12.230 0.000678 ***
## Dom               10.85   10.85     1 109.1   6.370 0.013043 *
## Season:Light       3.07    3.07     1 108.9   1.801 0.182342
## Season:Dom        13.08   13.08     1 109.1   7.681 0.006564 **
## Light:Dom          0.03    0.03     1 108.6   0.016 0.900351
## Season:Light:Dom   9.11    9.11     1 109.0   5.348 0.022628 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
posthoc<-emmeans(full, ~Dom:Light:Season)
CLD(posthoc, Letters=letters)
```

```
##  Dom    Light Season   emmean        SE    df lower.CL upper.CL .group
##  D   8.238607 winter 5.005924 0.4237749  9.88 4.060098 5.951751  a
##  C   8.238607 summer 5.090166 0.3452653  4.51 4.172822 6.007509  a
##  D   8.238607 summer 5.119654 0.6589125 42.24 3.790143 6.449166  ab
##  C   8.238607 winter 6.514512 0.3843448  6.70 5.597381 7.431643   b
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 4 estimates
```

```
## significance level used: alpha = 0.05
```

```r
plot(allEffects(full), ylab="total chlor", par.strip.text=list(cex=0.7))
```



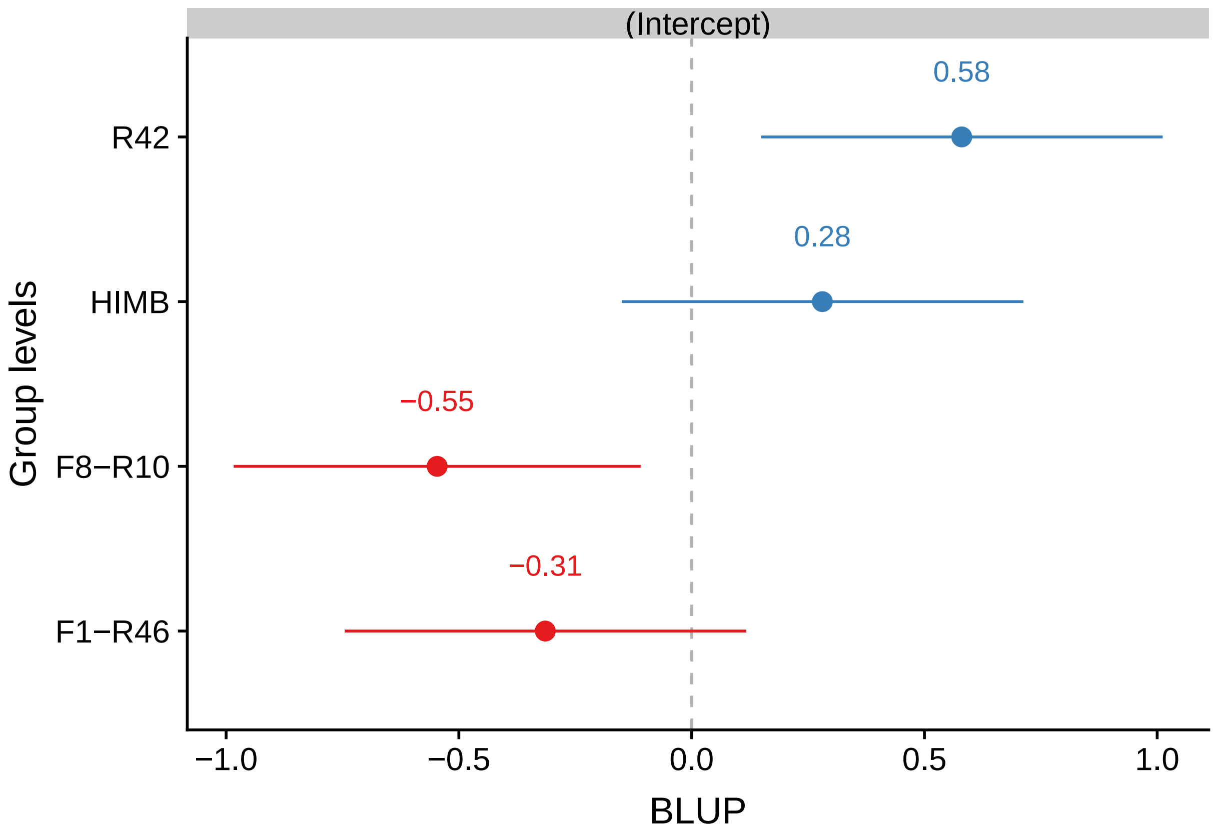

```r
ranef(full)
```

```
## $Location
##         (Intercept)
## F1-R46   -0.3143913
## F8-R10   -0.5466722
## HIMB      0.2808627
## R42       0.5802008
```

```r
fixef(full)
```

```
##            (Intercept)           Seasonwinter                  Light
##             5.42443464             2.64740866            -0.04057347
##                   DomD     Seasonwinter:Light      Seasonwinter:DomD
##             1.02243154            -0.14845501            -3.81871720
##             Light:DomD Seasonwinter:Light:DomD
##            -0.12052316             0.27682361
```

```r
sjp.lmer(full, y.offset = .4)
```



Chlorophyll per symbiont cell

```
######### chlcell --
Y<-model.data$chlcell
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use additive model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC   logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     6 13.914 30.588 -0.95686   1.9137
## object 10 18.546 46.337  0.72694  -1.4539 3.3676      4     0.4983
```

```
summary(add)
```

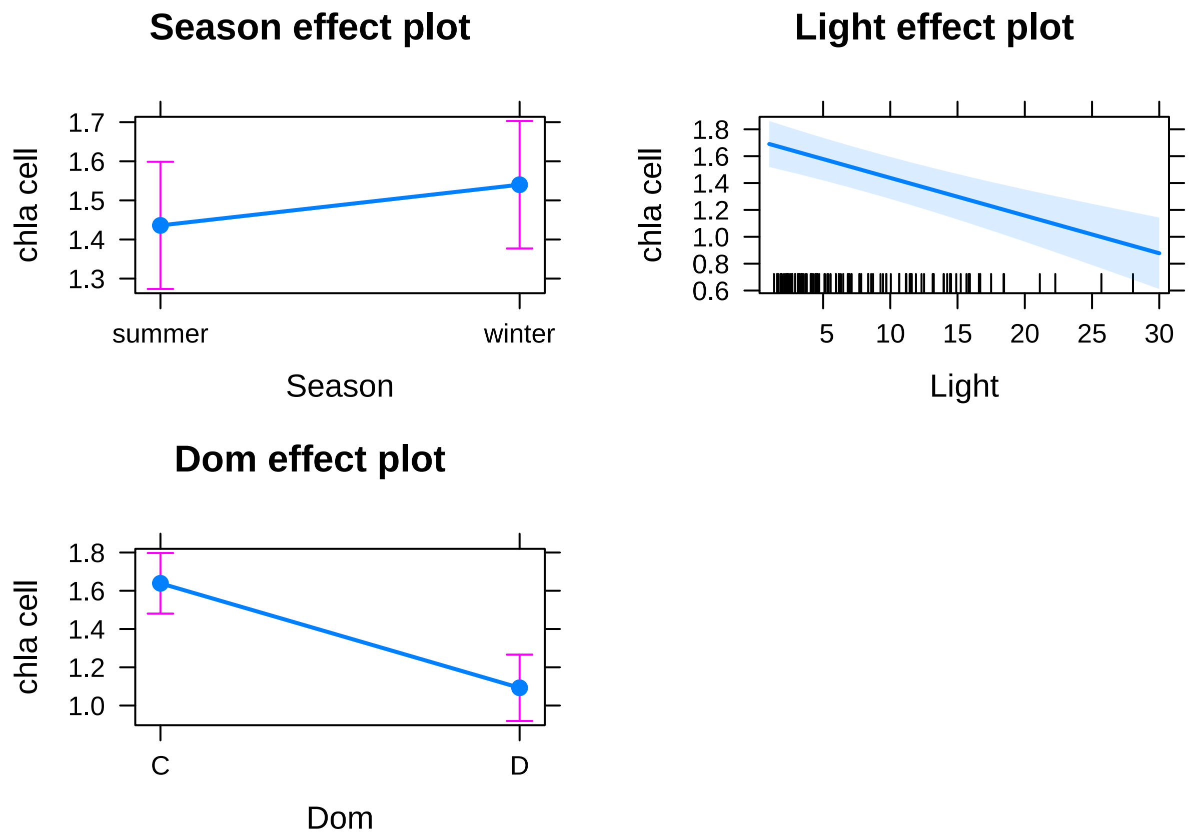
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 22.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.71851 -0.51819 -0.04947  0.47298  2.71238
##
```

```
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.02269  0.1506
##  Residual             0.05655  0.2378
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)    1.818462   0.094137   5.970000  19.317 1.31e-06 ***
## Seasonwinter   0.104004   0.049089 112.760000   2.119   0.0363 *
## Light         -0.028034   0.005004 114.570000  -5.603 1.47e-07 ***
## DomD          -0.546264   0.054293 112.810000 -10.061  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.419
## Light       -0.486  0.456
## DomD         0.089 -0.244 -0.426
```

```
print(anova(add, type=2), digits=5)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##        Sum Sq Mean Sq NumDF  DenDF F.value    Pr(>F)
## Season 0.2539  0.2539     1 112.76   4.489   0.03631 *
## Light  1.7754  1.7754     1 114.57  31.393 1.472e-07 ***
## Dom    5.7251  5.7251     1 112.81 101.232 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(allEffects(add), ylab="chla cell", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##         (Intercept)
## F1-R46 -0.01688154
## F8-R10 -0.19764101
## HIMB    0.10090019
## R42     0.11362236
```

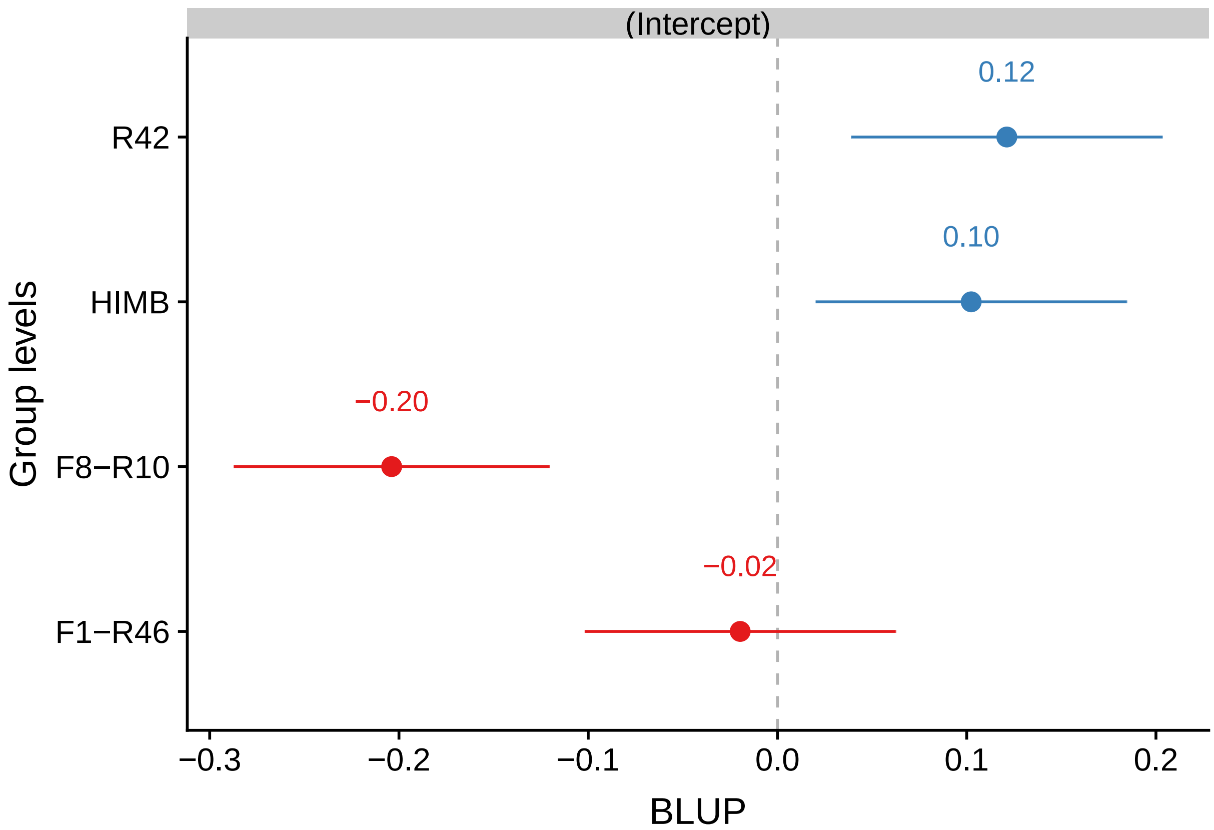
```r
rand(add)
```

```
## Analysis of Random effects Table:
##          Chi.sq Chi.DF p.value
## Location   19.8      1   9e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##  (Intercept) Seasonwinter        Light         DomD
##   1.81846170   0.10400380  -0.02803423  -0.54626369
```

```r
sjp.lmer(full, y.offset = .4)
```



isotopes

host d13C

```
########## host..d13C --
Y<-model.data$host..d13C
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use additive model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##         Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1      6 338.78 355.45 -163.39   326.78
## object 10 343.81 371.60 -161.91   323.81 2.9695      4     0.5629
```

```
summary(add)
```

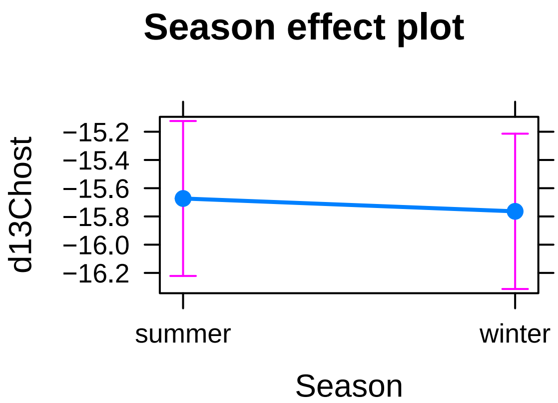
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 337
##
## Scaled residuals:
```

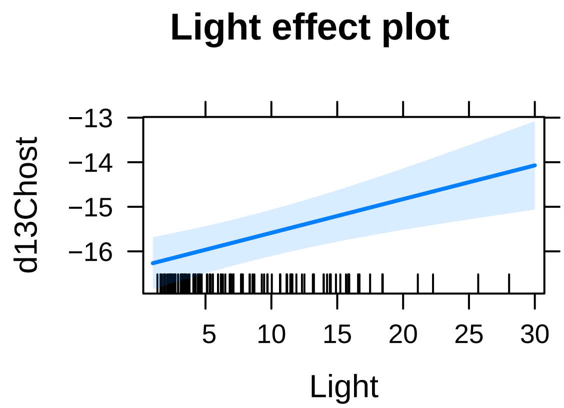
```
##      Min       1Q   Median       3Q      Max
## -2.66981 -0.68614 -0.03878  0.69141  2.21319
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.2409   0.4908
##  Residual             0.8772   0.9366
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##              Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)  -16.02988    0.33087   7.61000 -48.448 9.33e-11 ***
## Seasonwinter  -0.09107    0.19318 113.10000  -0.471 0.638238
## Light          0.07569    0.01964 114.96000   3.854 0.000192 ***
## DomD          -0.96124    0.21365 113.18000  -4.499 1.66e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.468
## Light       -0.543  0.455
## DomD         0.099 -0.243 -0.425
```

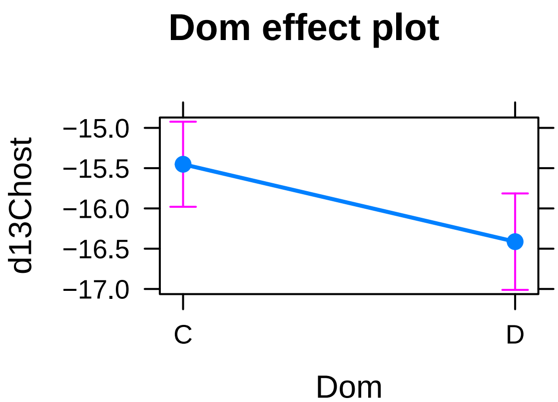
```
print(anova(add, type=2), digits=5)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##        Sum Sq Mean Sq NumDF  DenDF F.value    Pr(>F)
## Season  0.195   0.195     1 113.10  0.2223 0.6382382
## Light  13.029  13.029     1 114.96 14.8532 0.0001919 ***
## Dom    17.757  17.757     1 113.18 20.2430 1.662e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(allEffects(add), ylab="d13Chost", par.strip.text=list(cex=0.7))
```








```
ranef(add)
```

```
## $Location
##        (Intercept)
## F1-R46  -0.2856087
## F8-R10   0.3580103
## HIMB    -0.4978117
## R42      0.4254101
```

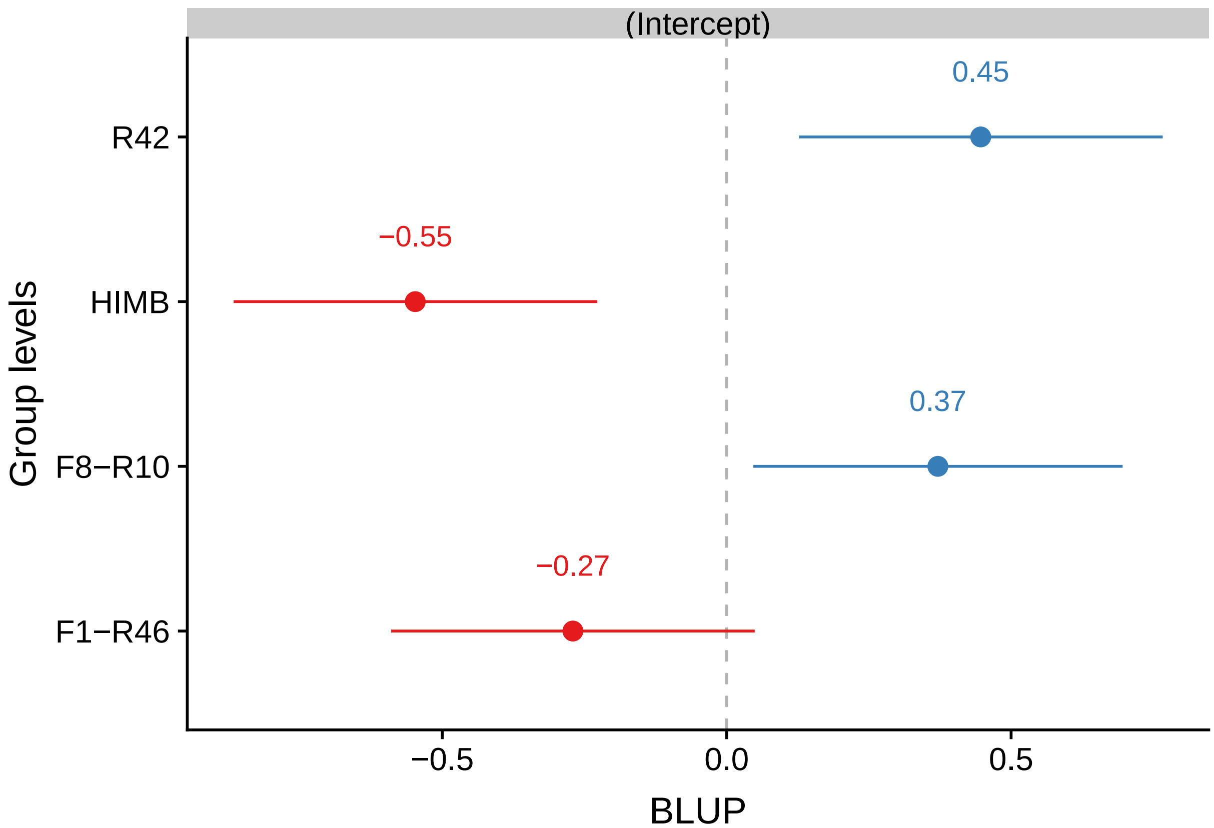
```
rand(add)
```

```
## Analysis of Random effects Table:
##          Chi.sq Chi.DF p.value
## Location   15.4      1   9e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
fixef(add)
```

```
##  (Intercept) Seasonwinter        Light         DomD
## -16.02988136  -0.09107261   0.07569224  -0.96124447
```

```
sjp.lmer(full, y.offset = .4)
```



symbiont d13C

```
########## symb..d13C --
Y<-model.data$symb..d13C
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use additive model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     6 353.38 370.05 -170.69   341.38
## object 10 354.11 381.90 -167.05   334.11 7.2693      4     0.1223
```

```
summary(add)
```

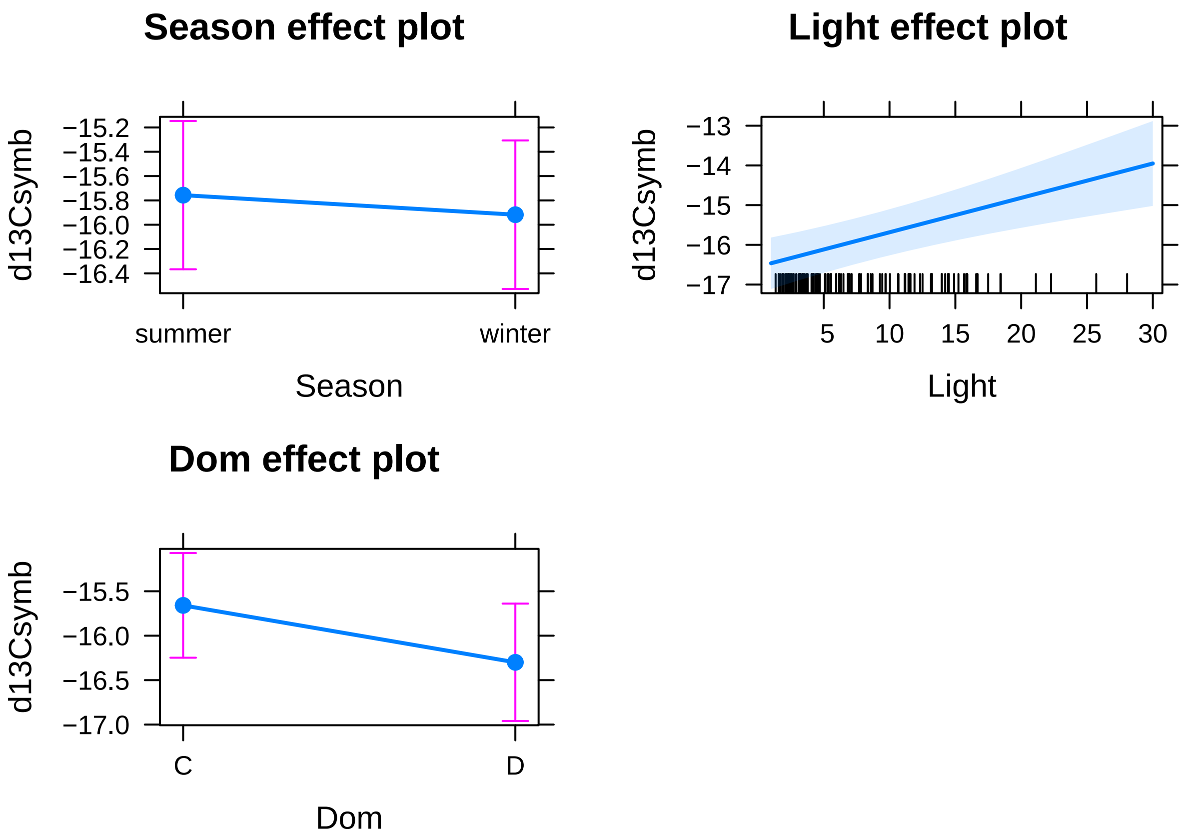
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 351
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.84081 -0.67259 -0.02418  0.72635  2.47022
##
```

```
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.3044   0.5518
##  Residual             0.9882   0.9941
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##               Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)  -16.29310    0.36289   7.08000 -44.899 5.93e-10 ***
## Seasonwinter  -0.16092    0.20510 113.00000  -0.785   0.4343
## Light          0.08666    0.02087 114.87000   4.153 6.34e-05 ***
## DomD          -0.64063    0.22683 113.07000  -2.824   0.0056 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.453
## Light       -0.526  0.455
## DomD         0.096 -0.243 -0.426
```

```r
print(anova(add, type=2), digits=5)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##         Sum Sq Mean Sq NumDF  DenDF F.value    Pr(>F)
## Season  0.6084  0.6084     1 113.00  0.6156  0.434329
## Light  17.0411 17.0411     1 114.87 17.2439 6.344e-05 ***
## Dom     7.8828  7.8828     1 113.07  7.9766  0.005602 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
plot(allEffects(add), ylab="d13Csymb", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##         (Intercept)
## F1-R46   -0.3459489
## F8-R10    0.5649621
## HIMB     -0.5305526
## R42       0.3115394
```

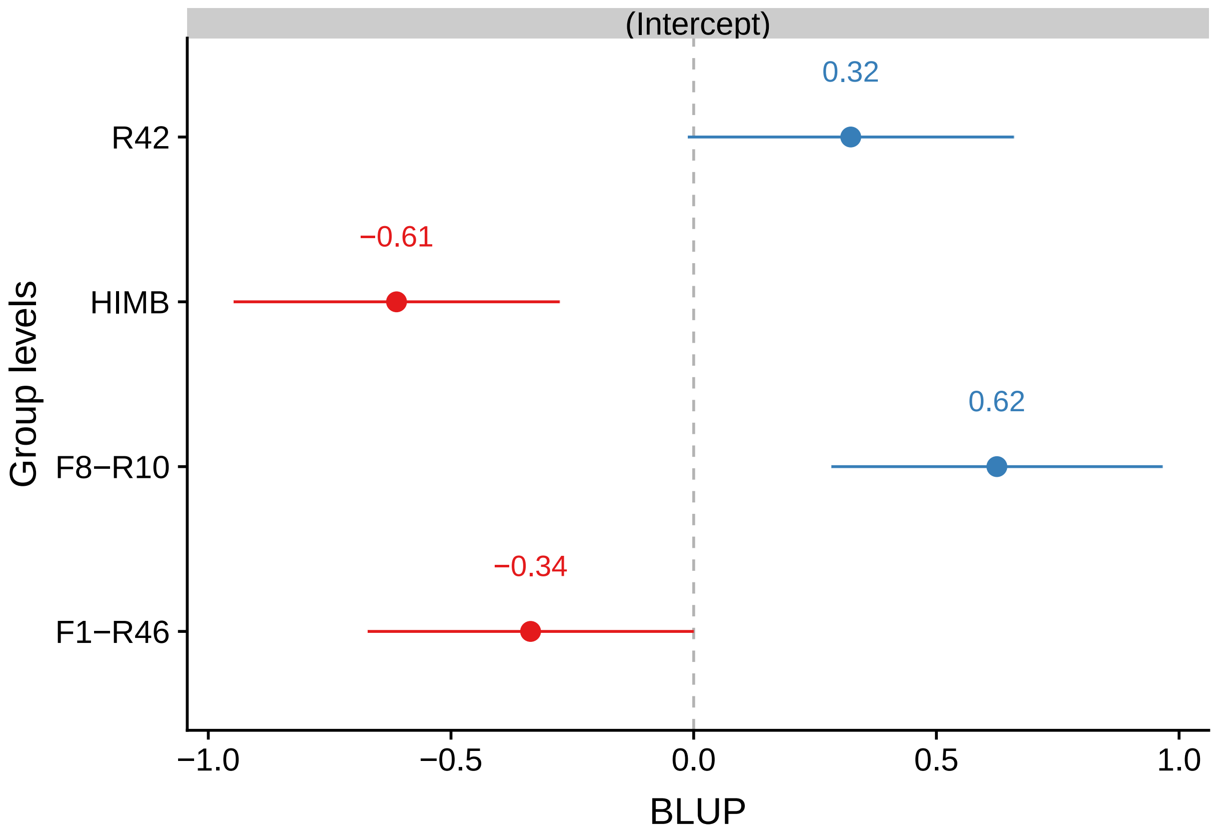
```r
rand(add)
```

```
## Analysis of Random effects Table:
##           Chi.sq Chi.DF p.value
## Location    17.2      1   3e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##  (Intercept) Seasonwinter        Light         DomD
## -16.29310412  -0.16092093   0.08666202  -0.64063417
```

```r
sjp.lmer(full, y.offset = .4)
```



host-symbiont d13C

```
######### d13C..host.sym --
Y<-model.data$d13C..host.sym
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ Season:Light +Season:Dom +(1|Location), data=model.data, na.action=na.exc
anova(full, add) #use add model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + Season:Light + Season:Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     8 27.618 49.851 -5.8091   11.618
## object 10 31.361 59.152 -5.6803   11.361 0.2575      2     0.8792
```

```
summary(add)
```

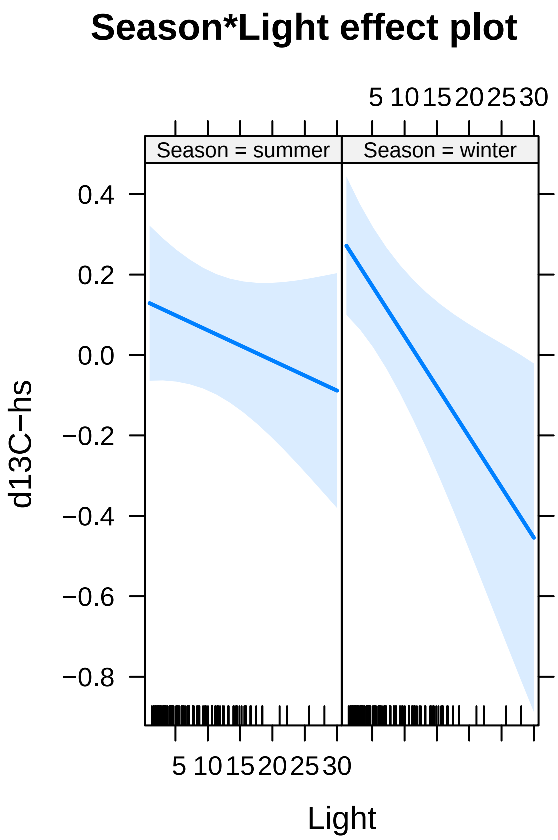
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula:
## Y ~ Season + Light + Dom + Season:Light + Season:Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 42.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -5.0874 -0.4662  0.0354  0.4346  3.0095
```

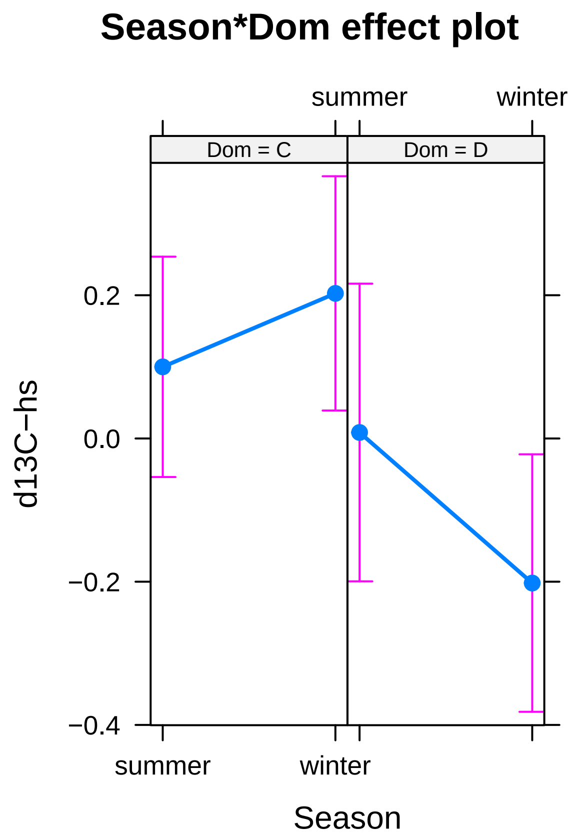
```
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.01849  0.1360
##  Residual             0.06304  0.2511
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                       Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)           0.161776   0.095670   8.780000   1.691  0.12596
## Seasonwinter          0.247105   0.087745 110.010000   2.816  0.00576 **
## Light                -0.007499   0.006498 111.750000  -1.154  0.25099
## DomD                 -0.091643   0.087006 110.550000  -1.053  0.29450
## Seasonwinter:Light   -0.017540   0.010292 110.650000  -1.704  0.09115 .
## Seasonwinter:DomD    -0.312838   0.115375 110.720000  -2.711  0.00777 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) Ssnwnt Light  DomD   Ssnw:L
## Seasonwintr -0.513
## Light       -0.585  0.592
## DomD         0.128 -0.116 -0.508
## Ssnwntr:Lgh  0.326 -0.757 -0.559  0.285
## Ssnwntr:DmD -0.088  0.023  0.370 -0.753 -0.372
```

```r
print(anova(add, type=2), digits=4)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##              Sum Sq Mean Sq NumDF DenDF F.value   Pr(>F)
## Season       0.5252  0.5252     1 110.0   8.330  0.00469 **
## Light        0.4347  0.4347     1 113.0   6.896  0.00984 **
## Dom          1.4148  1.4148     1 111.0  22.443 6.45e-06 ***
## Season:Light 0.1831  0.1831     1 110.7   2.904  0.09115 .
## Season:Dom   0.4635  0.4635     1 110.7   7.352  0.00777 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
plot(allEffects(add), ylab="d13C-hs", par.strip.text=list(cex=0.7))
```






```r
ranef(add)
```

```
## $Location
##         (Intercept)
## F1-R46   0.04127749
## F8-R10 -0.18899031
## HIMB     0.05229900
## R42      0.09541382
```

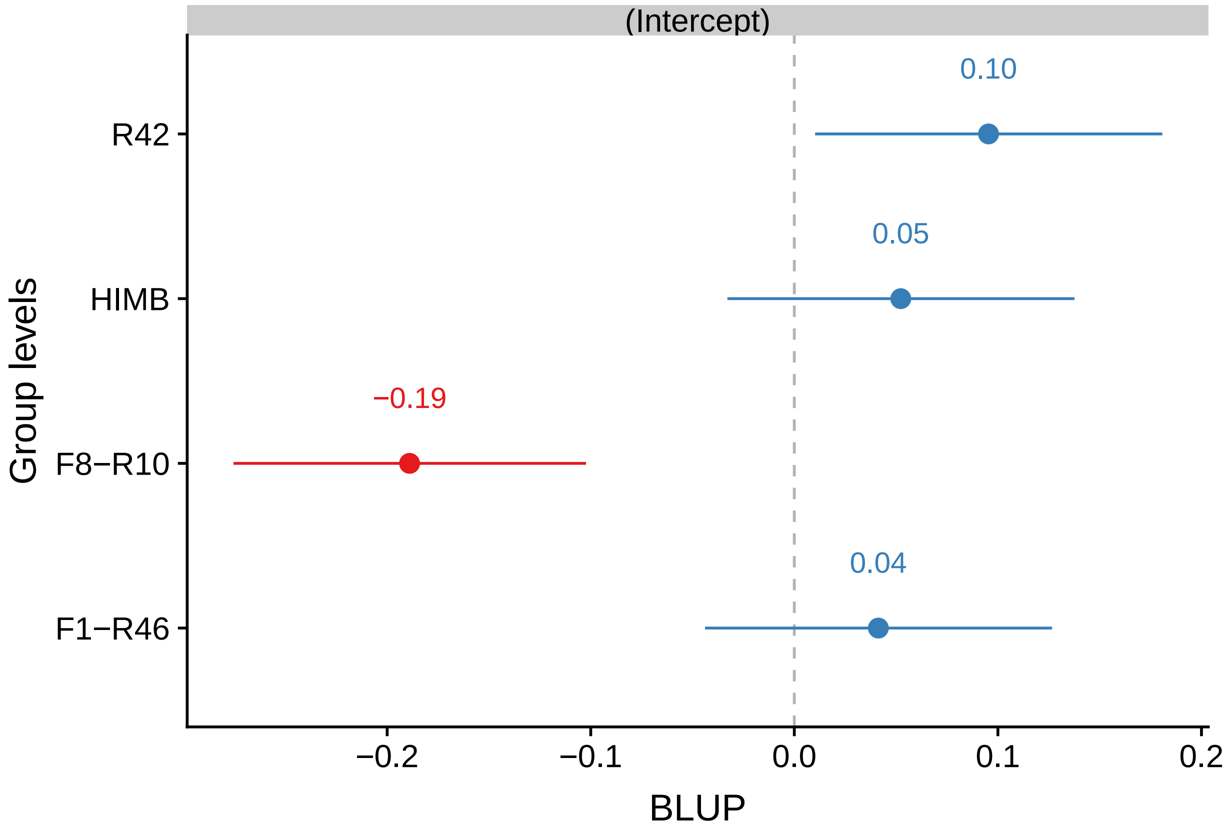
```r
rand(add)
```

```
## Analysis of Random effects Table:
##          Chi.sq Chi.DF p.value
## Location     13      1   3e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##         (Intercept)        Seasonwinter                Light
##          0.16177557          0.24710514          -0.00749862
##                DomD Seasonwinter:Light    Seasonwinter:DomD
##         -0.09164343         -0.01754001          -0.31283841
```

```r
sjp.lmer(add, y.offset = .4)
```



skeleton d13C

```
####### d13C..skel --
Y<-model.data$d13C..skel
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use full model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     6 310.41 327.09 -149.21   298.41
## object 10 315.48 343.27 -147.74   295.48 2.9331      4     0.5691
```

```
summary(add)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 309.9
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.96247 -0.80700  0.02393  0.68927  2.44873
##
```

```
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.1225   0.3501
##  Residual             0.7003   0.8368
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##               Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)   -2.62727    0.26398  10.18000  -9.953 1.44e-06 ***
## Seasonwinter   0.35828    0.17239 113.52000   2.078   0.0399 *
## Light         -0.01686    0.01745 114.75000  -0.966   0.3360
## DomD           0.15238    0.19064 113.62000   0.799   0.4258
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.521
## Light       -0.605  0.453
## DomD         0.108 -0.241 -0.423
```

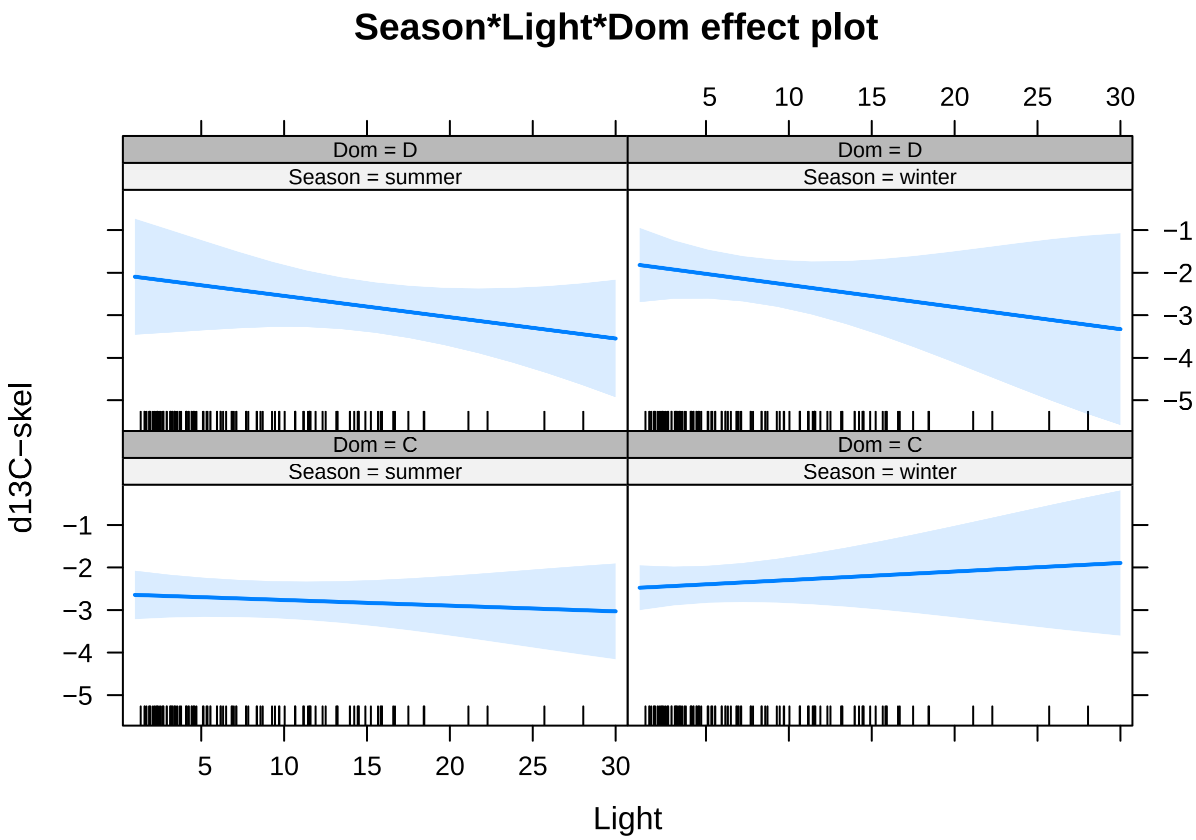
```
print(anova(add, type=2), digits=4)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##        Sum Sq Mean Sq NumDF DenDF F.value Pr(>F)
## Season 3.0248  3.0248     1 113.5   4.319 0.0399 *
## Light  0.6538  0.6538     1 114.8   0.934 0.3360
## Dom    0.4474  0.4474     1 113.6   0.639 0.4258
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
posthoc<-emmeans(add, ~Season)
CLD(posthoc, Letters=letters)
```

```
##  Season    emmean        SE   df  lower.CL  upper.CL .group
##  summer -2.690017 0.2179220 4.88 -3.254270 -2.125764  a
##  winter -2.331733 0.2101285 4.27 -2.901077 -1.762390   b
##
## Results are averaged over the levels of: Dom
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## significance level used: alpha = 0.05
```

```
plot(allEffects(full), ylab="d13C-skel", par.strip.text=list(cex=0.7))
```



host d15N

```
####### host..d15N --
Y<-model.data$host..d15N
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+Season:Light+ Season:Dom+ Light:Dom +(1|Location), data=model.data, na.act
anova(full, add) #use add model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + Season:Light + Season:Dom + Light:Dom +
## ..1:     (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC  logLik deviance Chisq Chi Df Pr(>Chisq)
## ..1     9 85.846 110.86 -33.923   67.846
## object 10 87.496 115.29 -33.748   67.496  0.35      1     0.5541
```

```
summary(add)
```

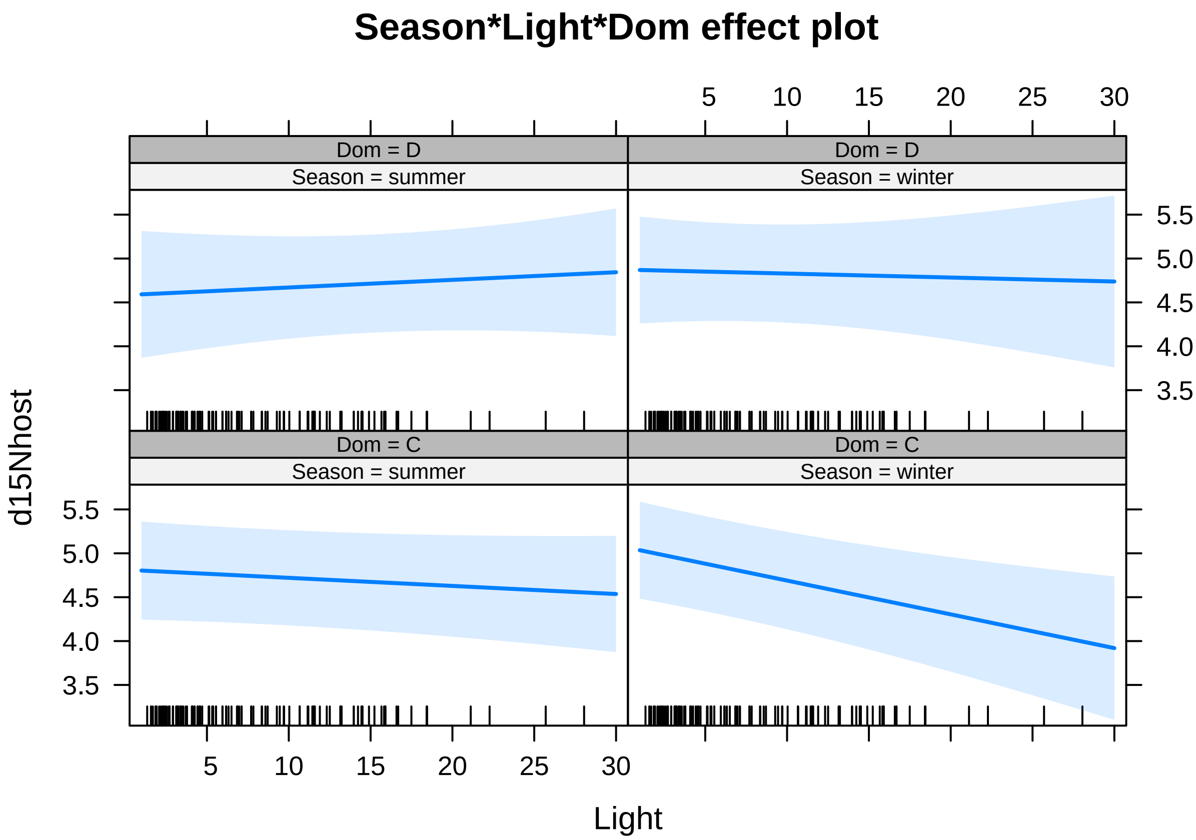
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula:
## Y ~ Season + Light + Dom + Season:Light + Season:Dom + Light:Dom +
##     (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 100.6
##
## Scaled residuals:
```

```
##      Min       1Q   Median       3Q      Max
## -2.87510 -0.49317 -0.02088  0.60805  2.07331
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.29361  0.5419
##  Residual             0.09454  0.3075
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                      Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)          4.825123   0.284627   3.570000  16.952 0.000153 ***
## Seasonwinter         0.232588   0.107773 109.020000   2.158 0.033113 *
## Light               -0.010659   0.008625 109.160000  -1.236 0.219161
## DomD                -0.321879   0.218258 109.080000  -1.475 0.143157
## Seasonwinter:Light  -0.024721   0.012630 109.080000  -1.957 0.052870 .
## Seasonwinter:DomD    0.187905   0.167453 109.070000   1.122 0.264268
## Light:DomD           0.024532   0.013811 109.050000   1.776 0.078484 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light  DomD   Ssnw:L Ssn:DD
## Seasonwintr -0.218
## Light       -0.261  0.572
## DomD        -0.059  0.009  0.097
## Ssnwntr:Lgh  0.130 -0.752 -0.498  0.167
## Ssnwntr:DmD  0.021 -0.021  0.089 -0.777 -0.332
## Light:DomD   0.098 -0.075 -0.376 -0.872 -0.034  0.535
```

```r
print(anova(add, type=2), digits=4)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##             Sum Sq Mean Sq NumDF DenDF F.value Pr(>F)
## Season       0.4478  0.4478     1 109.0   4.737 0.0317 *
## Light        0.3877  0.3877     1 109.5   4.101 0.0453 *
## Dom          0.0847  0.0847     1 109.1   0.896 0.3461
## Season:Light 0.3622  0.3622     1 109.1   3.831 0.0529 .
## Season:Dom   0.1190  0.1190     1 109.1   1.259 0.2643
## Light:Dom    0.2983  0.2983     1 109.0   3.155 0.0785 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
plot(allEffects(full), ylab="d15Nhost", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##          (Intercept)
## F1-R46    0.37281267
## F8-R10    0.05415004
## HIMB      0.35101369
## R42      -0.77797639
```

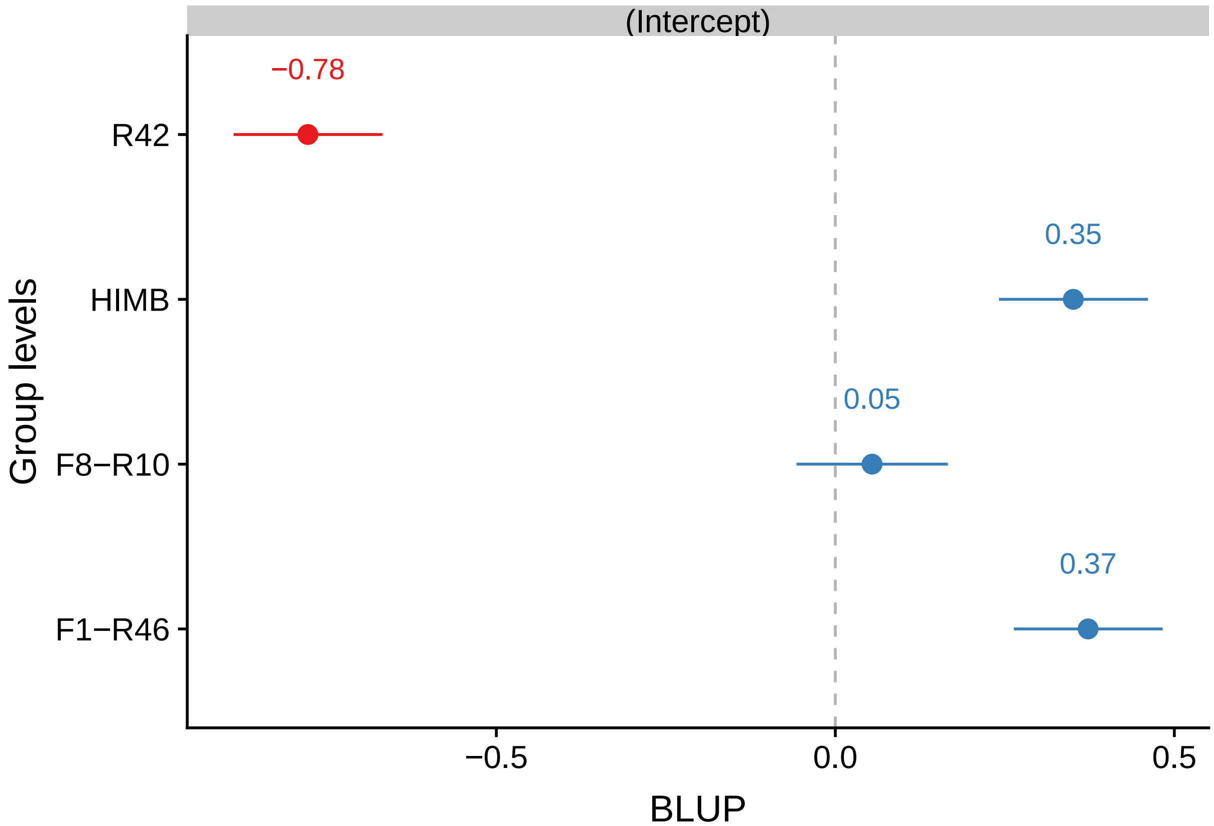
```r
rand(add)
```

```
## Analysis of Random effects Table:
##           Chi.sq Chi.DF p.value
## Location     121      1  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##          (Intercept)        Seasonwinter               Light
##           4.82512285          0.23258755         -0.01065915
##                 DomD Seasonwinter:Light   Seasonwinter:DomD
##          -0.32187911         -0.02472116          0.18790533
##           Light:DomD
##           0.02453174
```

```r
sjp.lmer(add, y.offset = .4)
```



symbiont d15N

```r
######## symb..d15N --
Y<-model.data$symb..d15N
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+Season:Light+ Season:Dom+ Light:Dom + (1|Location), data=model.data, na.ac
anova(full, add) #use full model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + Season:Light + Season:Dom + Light:Dom +
## ..1:     (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df    AIC    BIC  logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     9 94.163 119.17 -38.082   76.163
## object 10 95.262 123.05 -37.631   75.262 0.9013      1     0.3424
```

```r
summary(add)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula:
## Y ~ Season + Light + Dom + Season:Light + Season:Dom + Light:Dom +
##     (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 108.1
```

```
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.1583 -0.6369  0.1293  0.6237  2.2340
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.4455   0.6675
##  Residual             0.1002   0.3165
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                      Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)          4.258107   0.345609   3.390000  12.321 0.000618 ***
## Seasonwinter         0.017130   0.110941 109.010000   0.154 0.877575
## Light                0.005542   0.008879 109.110000   0.624 0.533867
## DomD                -0.453814   0.224684 109.060000  -2.020 0.045857 *
## Seasonwinter:Light  -0.011895   0.013002 109.050000  -0.915 0.362297
## Seasonwinter:DomD    0.548332   0.172381 109.050000   3.181 0.001912 **
## Light:DomD           0.026723   0.014217 109.040000   1.880 0.062838 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) Ssnwnt Light  DomD   Ssnw:L Ssn:DD
## Seasonwintr -0.185
## Light       -0.221  0.572
## DomD        -0.050  0.009  0.097
## Ssnwntr:Lgh  0.110 -0.752 -0.498  0.167
## Ssnwntr:DmD  0.018 -0.021  0.089 -0.777 -0.332
## Light:DomD   0.083 -0.075 -0.376 -0.872 -0.033  0.534
```

```r
print(anova(add, type=2), digits=3)
```

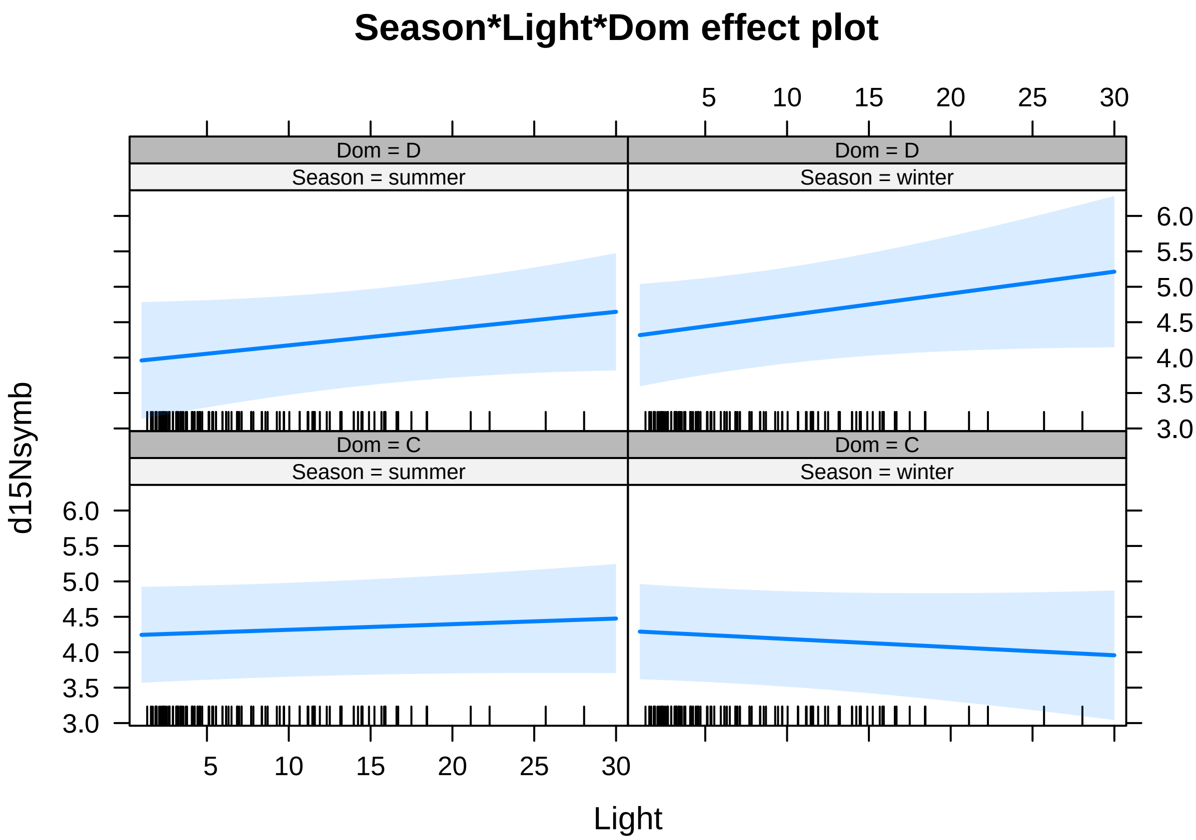
```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##              Sum Sq Mean Sq NumDF DenDF F.value Pr(>F)
## Season        0.004   0.004     1   109    0.04 0.8377
## Light         0.140   0.140     1   109    1.39 0.2404
## Dom           0.056   0.056     1   109    0.56 0.4552
## Season:Light  0.084   0.084     1   109    0.84 0.3623
## Season:Dom    1.014   1.014     1   109   10.12 0.0019 **
## Light:Dom     0.354   0.354     1   109    3.53 0.0628 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
posthoc<-emmeans(full, ~Season*Dom)
CLD(posthoc, Letters=letters)
```

```
##  Season Dom   emmean        SE   df lower.CL upper.CL .group
##  summer D   4.131481 0.3610092 4.17 3.144705 5.118257  ab
##  winter C   4.207585 0.3368824 3.16 3.166021 5.249150  a
##  summer C   4.302891 0.3343979 3.07 3.252439 5.353343  a
##  winter D   4.540954 0.3396607 3.27 3.508523 5.573385   b
##
```

```
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 4 estimates
## significance level used: alpha = 0.05
```

```r
plot(allEffects(full), ylab="d15Nsymb", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##        (Intercept)
## F1-R46   0.4132212
## F8-R10   0.1547304
## HIMB     0.4122555
## R42     -0.9802071
```

```r
rand(add)
```

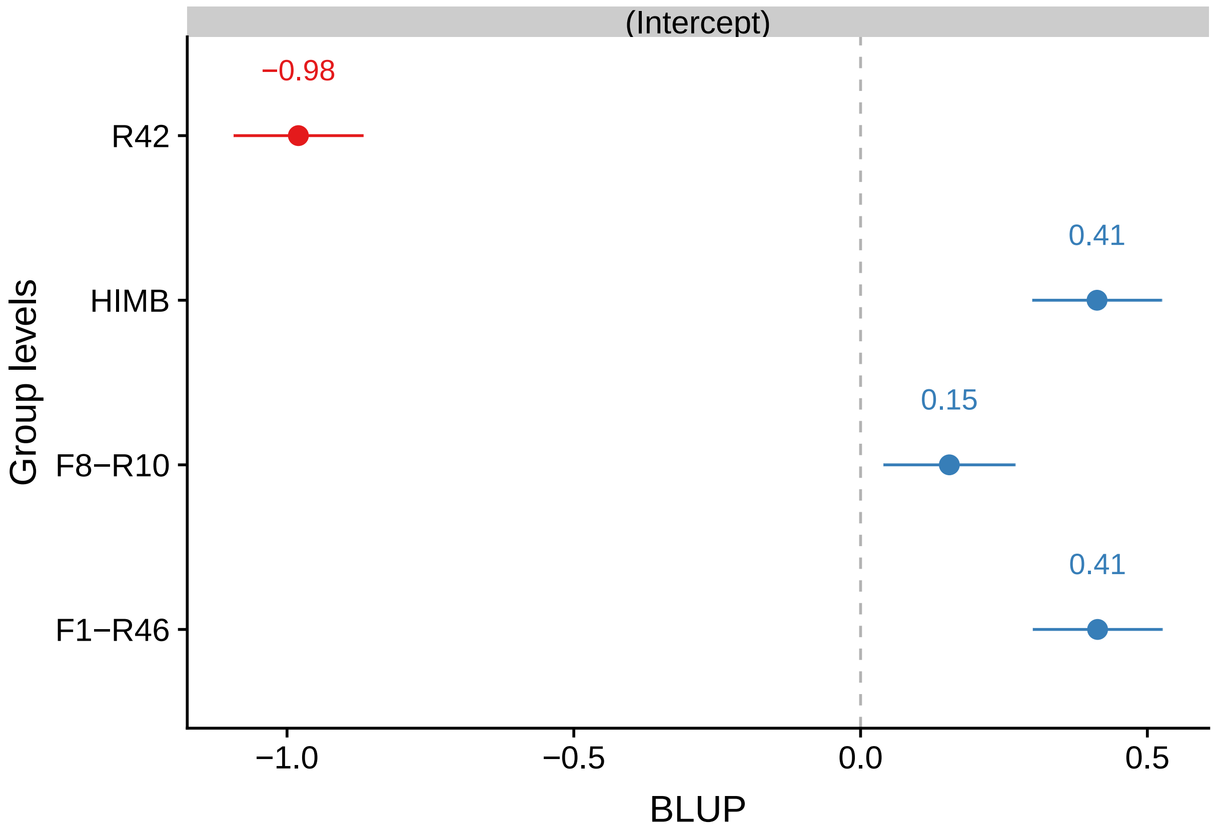
```
## Analysis of Random effects Table:
##          Chi.sq Chi.DF p.value
## Location    148      1  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##        (Intercept)        Seasonwinter               Light
##        4.258107245         0.017130046         0.005541514
##               DomD Seasonwinter:Light   Seasonwinter:DomD
##       -0.453814481        -0.011894857         0.548331654
```

```
##          Light:DomD
##         0.026722563
```

```
sjp.lmer(add, y.offset = .4)
```



host-symbiont d15N

```
####### d15N..host.sym  --
Y<-model.data$d15N..host.sym
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ Season:Dom+  (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use full model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + Season:Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df     AIC    BIC logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     7 -7.7053 11.748 10.853  -21.705
## object 10 -4.1556 23.636 12.078  -24.156 2.4503      3     0.4843
```

```
summary(add)
```

```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + Season:Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: 3
##
```

```
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.87449 -0.73818  0.03548  0.69225  2.33677
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.01553  0.1246
##  Residual             0.04706  0.2169
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##                     Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)         0.601672   0.080872   6.670000   7.440 0.000183 ***
## Seasonwinter        0.135546   0.049510 111.600000   2.738 0.007201 **
## Light              -0.020248   0.004662 113.850000  -4.343 3.06e-05 ***
## DomD                0.126465   0.072076 111.850000   1.755 0.082064 .
## Seasonwinter:DomD  -0.399543   0.092535 111.800000  -4.318 3.42e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light  DomD
## Seasonwintr -0.417
## Light       -0.496  0.312
## DomD         0.038  0.159 -0.439
## Ssnwntr:DmD  0.036 -0.427  0.211 -0.727
```

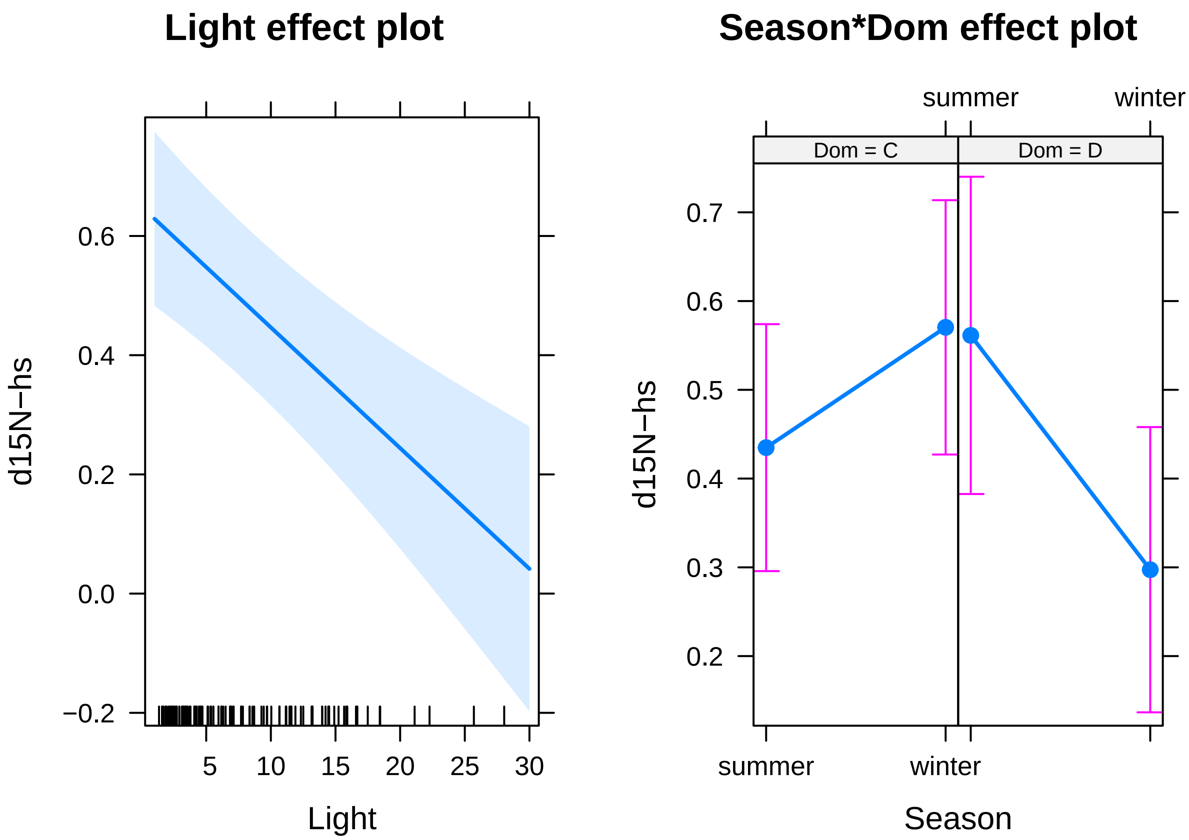
```r
print(anova(add, type=2), digits=3)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##            Sum Sq Mean Sq NumDF DenDF F.value  Pr(>F)
## Season      0.040   0.040     1   112    0.85   0.358
## Light       0.888   0.888     1   114   18.86 3.1e-05 ***
## Dom         0.194   0.194     1   112    4.13   0.044 *
## Season:Dom  0.877   0.877     1   112   18.64 3.4e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
posthoc<-emmeans(full, ~Season*Dom)
CLD(posthoc, Letters=letters)
```

```
##  Season Dom    emmean         SE    df   lower.CL  upper.CL .group
##  winter D   0.2936771 0.08195540  6.80 0.09871493 0.4886394  a
##  summer C   0.4335578 0.07100439  3.88 0.23408224 0.6330333  ab
##  summer D   0.5112646 0.11739577 25.04 0.26950469 0.7530245  ab
##  winter C   0.5553393 0.07636443  5.13 0.36050544 0.7501731   b
##
## Degrees-of-freedom method: kenward-roger
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 4 estimates
## significance level used: alpha = 0.05
```

```r
plot(allEffects(add), ylab="d15N-hs", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##          (Intercept)
## F1-R46 -0.04191457
## F8-R10 -0.08161716
## HIMB   -0.05201146
## R42     0.17554320
```

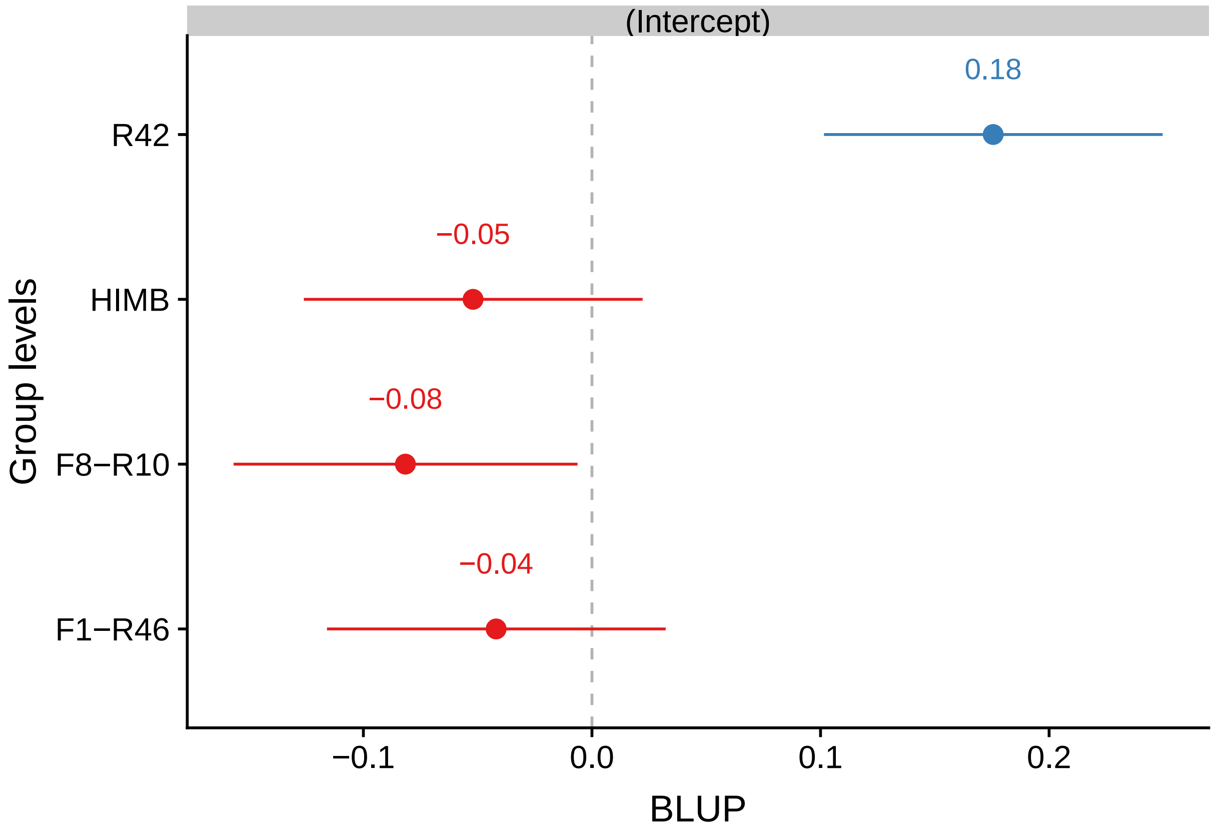
```r
rand(add)
```

```
## Analysis of Random effects Table:
##           Chi.sq Chi.DF p.value
## Location    16.4      1   5e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##       (Intercept)      Seasonwinter             Light              DomD
##        0.60167221        0.13554584       -0.02024803        0.12646507
## Seasonwinter:DomD
##       -0.39954308
```

```r
sjp.lmer(add, y.offset = .4)
```



host C:N

```r
###### host..C.N --
Y<-model.data$host..C.N
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use full model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df     AIC     BIC logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     6 -271.85 -255.18 141.93  -283.85
## object 10 -268.06 -240.27 144.03  -288.06 4.2107      4     0.3782
```

```r
summary(add)
```

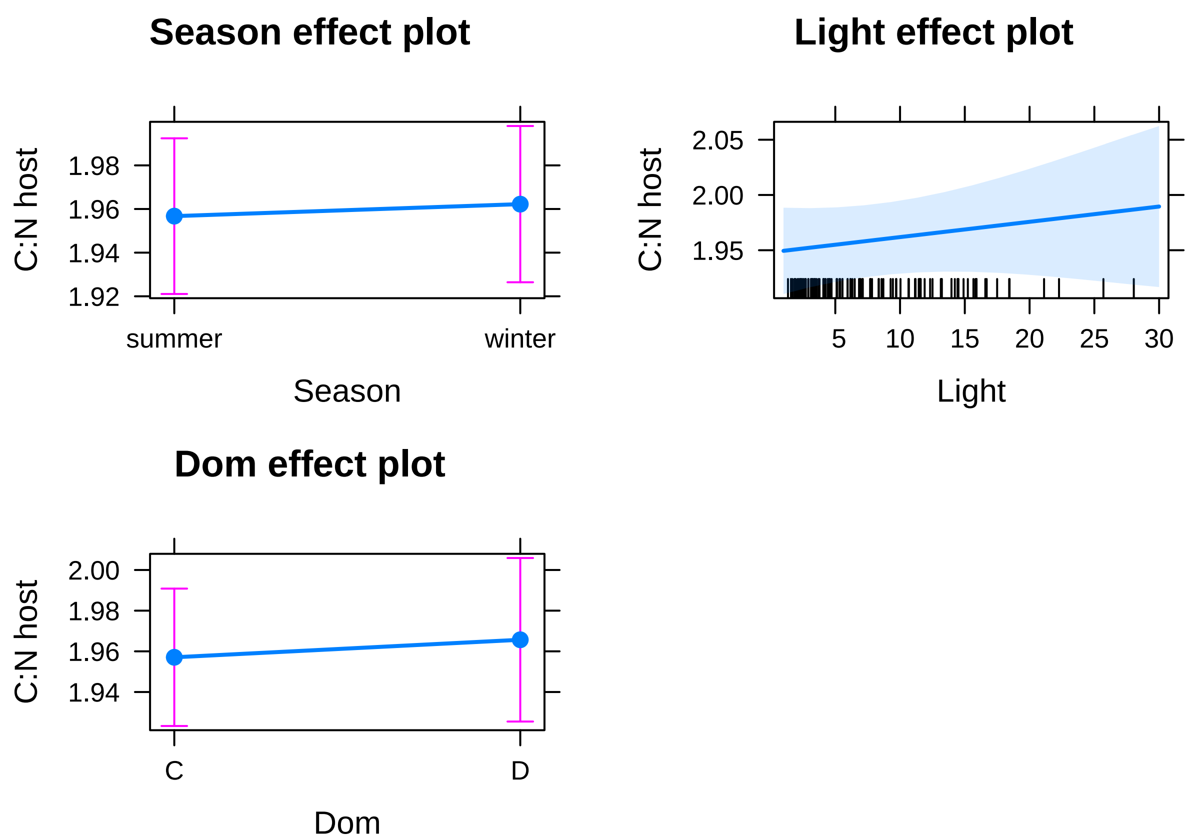
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: -252.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
```

```
## -1.84607 -0.73952 -0.04315  0.66611  3.15900
##
## Random effects:
##  Groups   Name        Variance  Std.Dev.
##  Location (Intercept) 0.0009024 0.03004
##  Residual             0.0052547 0.07249
## Number of obs: 119, groups:  Location, 4
##
## Fixed effects:
##               Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)  1.943e+00  2.277e-02 9.890e+00  85.327 1.78e-15 ***
## Seasonwinter 5.501e-03  1.493e-02 1.135e+02   0.368    0.713
## Light        1.382e-03  1.512e-03 1.147e+02   0.914    0.362
## DomD         8.612e-03  1.651e-02 1.136e+02   0.522    0.603
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.523
## Light       -0.607  0.452
## DomD         0.108 -0.241 -0.423
```

```
print(anova(add, type=2), digits=4)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##          Sum Sq  Mean Sq NumDF DenDF F.value Pr(>F)
## Season 0.000713 0.000713     1 113.5  0.1357  0.713
## Light  0.004394 0.004394     1 114.7  0.8361  0.362
## Dom    0.001429 0.001429     1 113.6  0.2720  0.603
```

```
plot(allEffects(add), ylab="C:N host", par.strip.text=list(cex=0.7))
```




```r
ranef(add)
```

```
## $Location
##         (Intercept)
## F1-R46 -0.00994385
## F8-R10  0.02064641
## HIMB    0.02340875
## R42    -0.03411131
```

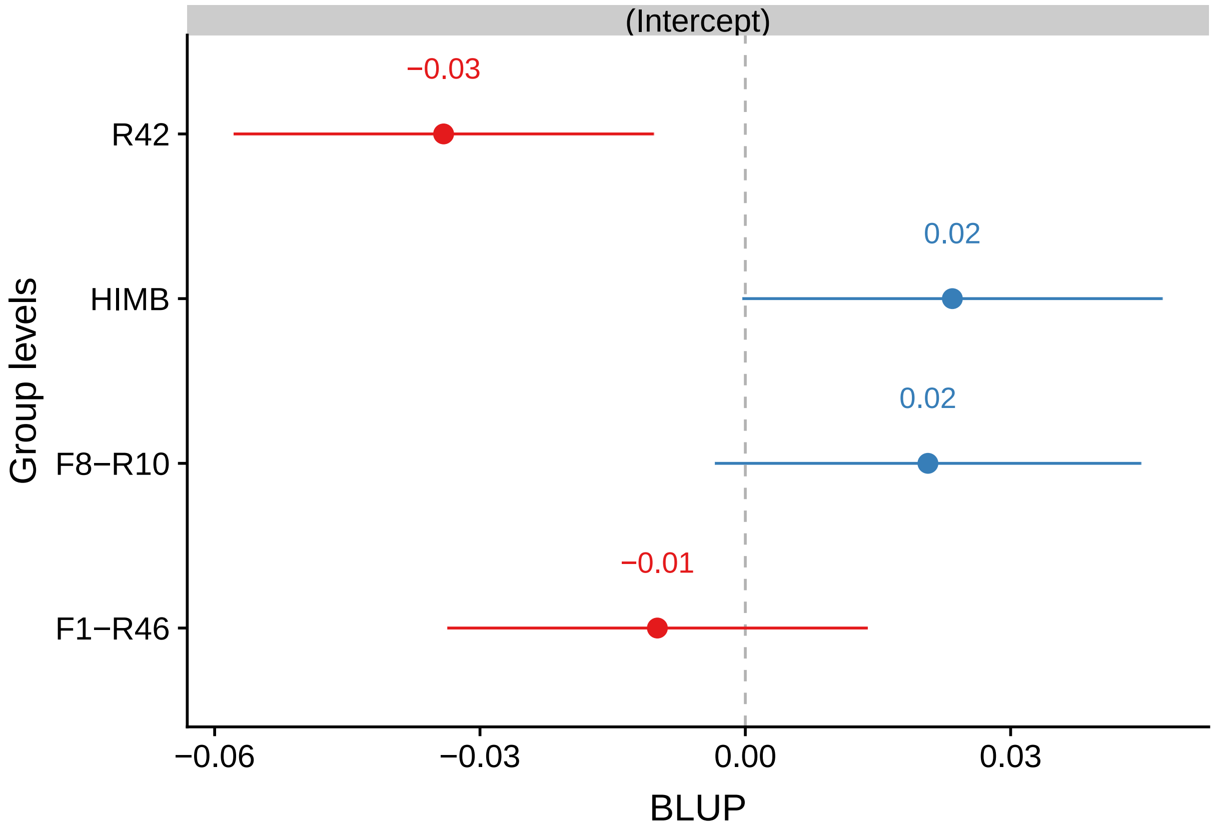
```r
rand(add)
```

```
## Analysis of Random effects Table:
##            Chi.sq Chi.DF p.value
## Location    7.57      1   0.006 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
fixef(add)
```

```
##  (Intercept) Seasonwinter        Light         DomD
##  1.942951666  0.005501474  0.001382129  0.008612347
```

```r
sjp.lmer(add, y.offset = .4)
```



symbiont C:N

```
####### symb..C.N --
Y<-model.data$symb..C.N
full<-lmer(Y~Season*Light*Dom+ (1|Location), data=model.data, na.action=na.exclude)
add<-lmer(Y~Season+Light+Dom+ (1|Location), data=model.data, na.action=na.exclude)
anova(full, add) #use full model
```

```
## Data: model.data
## Models:
## ..1: Y ~ Season + Light + Dom + (1 | Location)
## object: Y ~ Season * Light * Dom + (1 | Location)
##        Df     AIC     BIC logLik deviance  Chisq Chi Df Pr(>Chisq)
## ..1     6 -210.70 -194.07 111.35  -222.70
## object 10 -207.75 -180.04 113.88  -227.75 5.0519      4      0.282
```

```
summary(add)
```

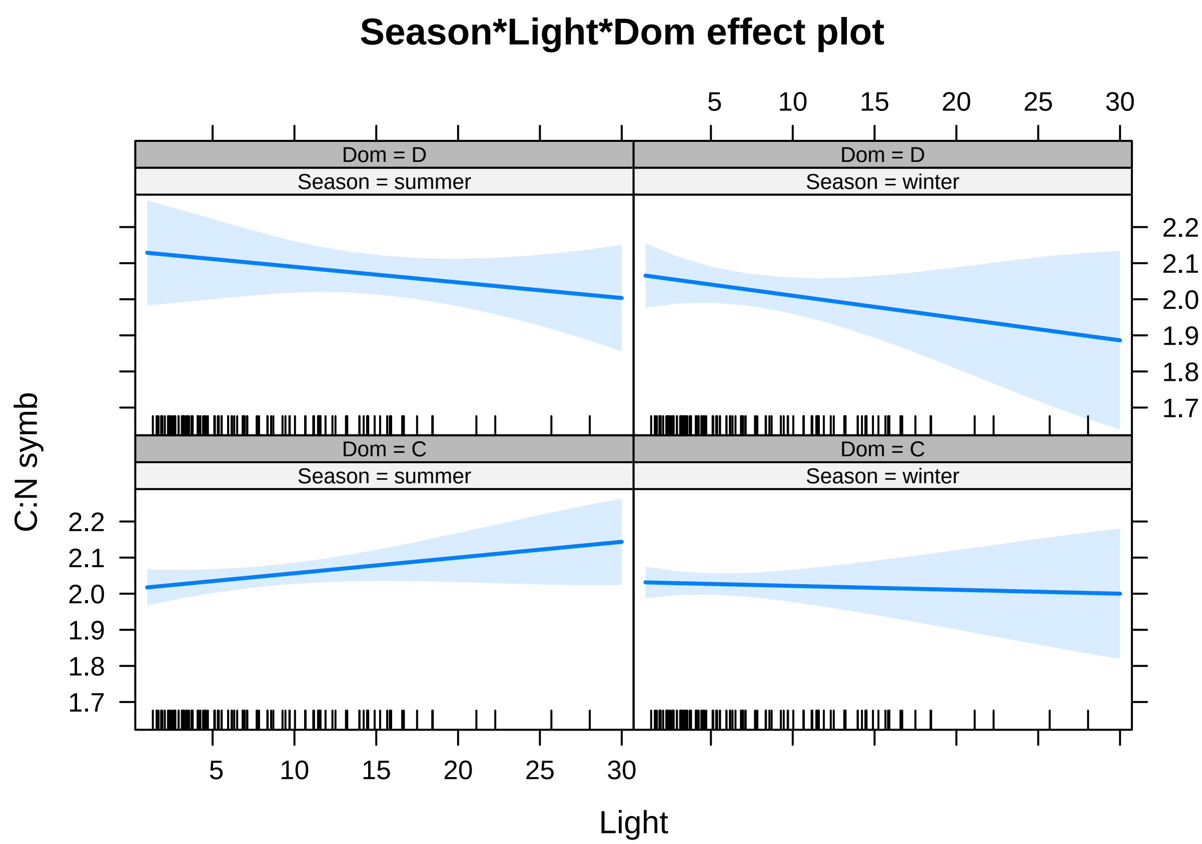
```
## Linear mixed model fit by REML t-tests use Satterthwaite approximations
##   to degrees of freedom [lmerMod]
## Formula: Y ~ Season + Light + Dom + (1 | Location)
##    Data: model.data
##
## REML criterion at convergence: -192
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.8765 -0.6378 -0.1564  0.6934  2.9317
##
```

```
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Location (Intercept) 0.00000  0.00000
##  Residual             0.00918  0.09581
## Number of obs: 118, groups:  Location, 4
##
## Fixed effects:
##                Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)   2.048e+00  2.155e-02  1.140e+02  95.038   <2e-16 ***
## Seasonwinter -2.715e-02  1.945e-02  1.140e+02  -1.396    0.165
## Light         5.587e-04  1.849e-03  1.140e+02   0.302    0.763
## DomD          2.871e-03  2.143e-02  1.140e+02   0.134    0.894
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) Ssnwnt Light
## Seasonwintr -0.678
## Light       -0.786  0.416
## DomD         0.099 -0.220 -0.394
```

```r
print(anova(add, type=2), digits=5)
```

```
## Analysis of Variance Table of type II  with  Satterthwaite
## approximation for degrees of freedom
##           Sum Sq   Mean Sq NumDF DenDF F.value Pr(>F)
## Season 0.0178944 0.0178944     1   114 1.94918 0.1654
## Light  0.0008386 0.0008386     1   114 0.09135 0.7630
## Dom    0.0001649 0.0001649     1   114 0.01796 0.8936
```

```r
plot(allEffects(full), ylab="C:N symb", par.strip.text=list(cex=0.7))
```

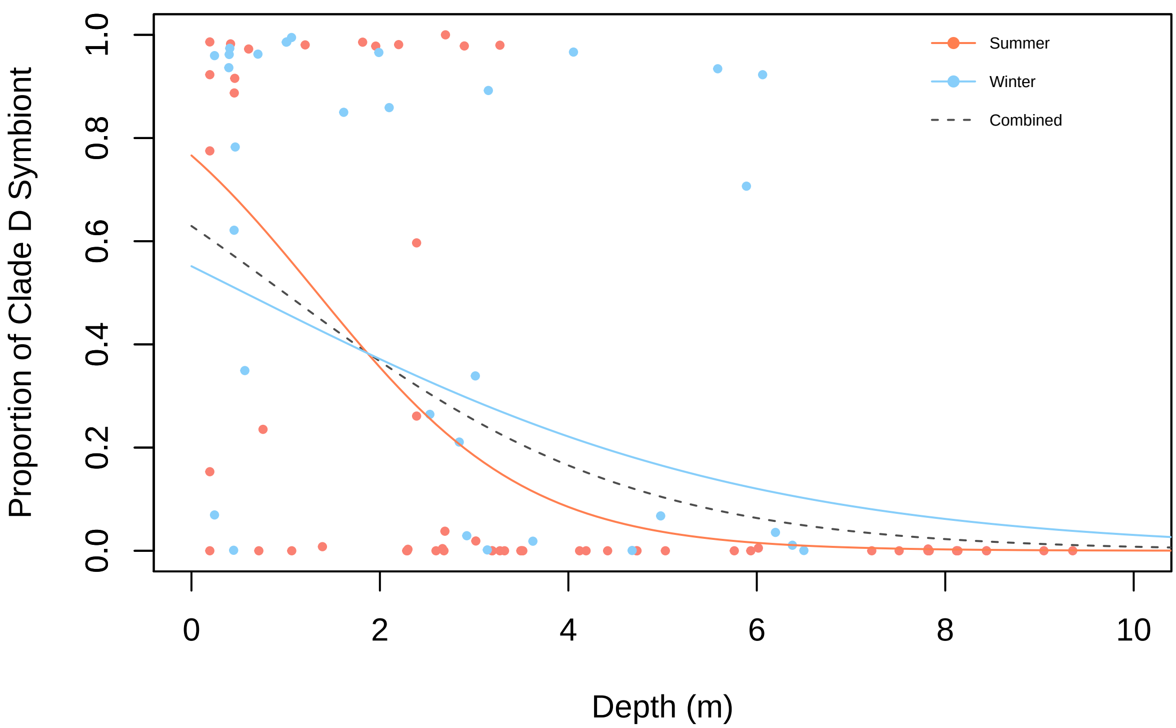


Figures

qPCR figures

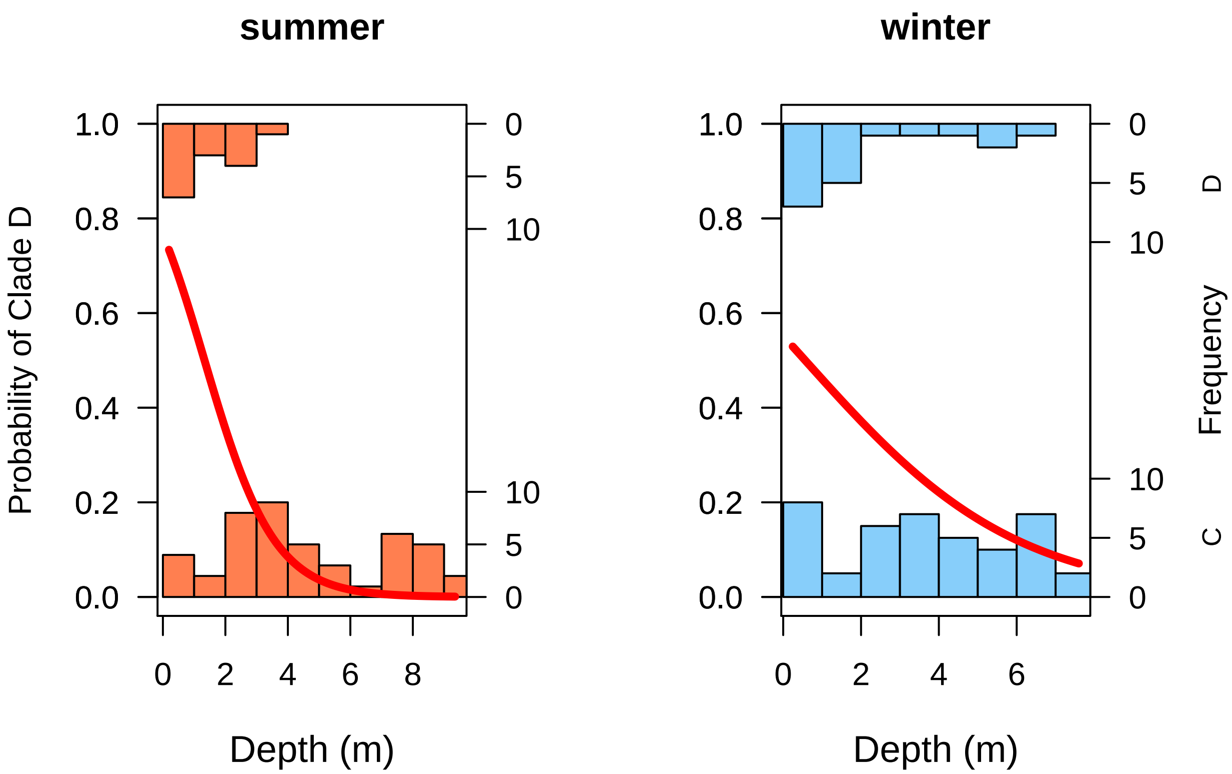
```
## Figures
#########################
#########################
#########################

#qPCR and symbionts

#########################
###### Plot Dominant Symbiont and Depth (both seasons)
Symb<-model.data
Symb$Dominant <- ifelse(Symb$Dom=="D", 1, 0)
results.all=glm(Dominant~newDepth, family = "binomial", data = Symb)
anova(results.all, test = "Chisq")
summary(results.all)
fitted.all <- predict(results.all, newdata = list(newDepth=seq(0,12,0.1)), type = "response")
# plot(fitted.all, ylab="proportion D", ylim=c(0,1))

###### summer only symbionts
sum.dat<-Symb[(Symb$Season=="summer"),]
results.sum=glm(Dominant~newDepth, family = "binomial", data = sum.dat)
anova(results.sum, test = "Chisq")
summary(results.sum)
fitted.sum <- predict(results.sum, newdata = list(newDepth=seq(0,12,0.1)), type = "response")
```

```
# plot(fitted.sum, ylab="proportion D", ylim=c(0,1))

###### winter only symbionts
wint.dat<-Symb[(Symb$Season=="winter"),]
results.win=glm(Dominant~newDepth, family = "binomial", data = wint.dat)
anova(results.win, test = "Chisq")
summary(results.win)
fitted.win <- predict(results.win, newdata = list(newDepth=seq(0,12,0.1)), type = "response")
# plot(fitted.win, ylab="proportion D", ylim=c(0,1))

######
######
## Figure of Dominant symbiont clades across seasons
## **Note** where points equal 0.0 is 100% D, where they equal 0 is 100% C
par(mar=c(5,4,3,2))
plot(sum.dat$propD~sum.dat$newDepth, xlab="Depth (m)", ylab = "Proportion of Clade D Symbiont", pch=19,
par(new=T)
plot(wint.dat$propD~wint.dat$newDepth, pch=19, col="lightskyblue", xlim=c(0,10), ylim=c(0.0, 1.0), xaxt=
lines(fitted.all ~ seq(0,12,0.1), col="gray30", lwd=1, lty=2)
lines(fitted.sum ~ seq(0,12,0.1), col="coral", lwd=1)
lines(fitted.win ~ seq(0,12,0.1), col="lightskyblue", lwd=1)
legend("topright", pch=c(19,19, NA), lty=c(1,1,2), col=c("coral", "lightskyblue", "gray30"), legend=c("S
```




```
dev.copy(pdf, "figures/symbionts/Symbionts_by_Season.pdf", encod="MacRoman", height=4, width=4)
dev.off()

#######
#######
par(mfrow=c(1,2))
Dom1 <- subset(Symb, !is.na(newDepth) & !is.na(Dominant))
```

```r
Dom.sum<-Dom1[(Dom1$Season=="summer"),]
Dom.win<-Dom1[(Dom1$Season=="winter"),]

logi.hist.plot(Dom.sum$newDepth, Dom.sum$Dominant, boxp = FALSE, type = "hist", col="coral", xlabel = "
mtext(side = 2, text = "Probability of Clade D", line = 3, cex = 1)

logi.hist.plot(Dom.win$newDepth, Dom.win$Dominant, boxp = FALSE, type = "hist", col="lightskyblue", xla
mtext(side = 4, text = "Frequency", line = 0.5, cex=1)
mtext(side = 4, text = "C                                          D", line = 0.5, cex = 0.8)
```




```r
dev.copy(pdf, "figures/symbionts/Symbionts_Season_logistic.pdf", encod="MacRoman", height=5, width=8)
dev.off()
```

Physiology

```r
#########################
# Physiology
df.fig<-data.trim
# figure layout
layout(matrix(c(1,1,2,3), 2,2, byrow=TRUE))
par(mar=c(5,4.5,2,2))

##################
##################

## season relationship
data.summer<-df.fig[df.fig$Season=="summer", ]
data.winter<-df.fig[df.fig$Season=="winter", ]
```

```r
## Site relationship
F8.R10.df<-df.fig[df.fig$Location=="F8-R10", ]
F1.R46.df<-df.fig[df.fig$Location=="F1-R46", ]
HIMB.df<-df.fig[df.fig$Location=="HIMB", ]
R42.df<-df.fig[df.fig$Location=="R42", ]

## Symbiont relationship
C.sum.df<-df.fig[(df.fig$Dom=="C" & df.fig$Season=="summer") ,]
C.win.df<-df.fig[(df.fig$Dom=="C" & df.fig$Season=="winter") ,]; C.win.df<-na.omit(C.win.df)
D.sum.df<-df.fig[(df.fig$Dom=="D" & df.fig$Season=="summer") ,]; D.sum.df<-na.omit(D.sum.df)
D.win.df<-df.fig[(df.fig$Dom=="D" & df.fig$Season=="winter") ,]; D.win.df<-na.omit(D.win.df)

##################
# Fig: chlorophyll (total) over season and depth
##################

plot(chltot~newDepth, data=data.winter,col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")),
     main="chl: Depth and Season",
     xlim=c(0,11), ylim=c(1,17))
abline((lm(chltot~newDepth, data=data.winter)), col='dodgerblue3', lwd=2)
points(chltot~newDepth, data=data.summer, col="tomato2", pch=16, cex=0.7)
abline((lm(chltot~newDepth, data=data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(data.winter$chltot), ylim=c(0,0.3), xlim=c(0, 18), col="dodgerblue3", main="chl: Seasons",
     xlab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")))
lines(density(data.summer$chltot), col="tomato2")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.35


###### density plot: by Site
plot(density(F1.R46.df$chltot), ylim=c(0,0.3), xlim=c(0, 18), col="tomato2", main="chl: Sites",
     xlab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")), ylab="Density")
lines(density(R42.df$chltot), col="skyblue3")
lines(density(F8.R10.df$chltot), col="springgreen4")
lines(density(HIMB.df$chltot), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))
dev.copy(pdf, "figures/physiology/PanKB.chl.pdf", width=9, height=7)



##################
# Fig: chlorophyll (total) over season and depth
##################

plot(chltot~Light, data=C.sum.df,col="tomato2", pch=16, cex=0.7,
     xlab="Light (DLI)", ylab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")),
     main="chl: Light and Season",
```

```
     xlim=c(0,20), ylim=c(1,12))
abline((lm(chltot~Light, data=C.sum.df)), col='tomato2', lwd=2)
points(chltot~Light, data=C.win.df, col="dodgerblue3", pch=16, cex=0.7)
abline((lm(chltot~Light, data=C.win.df)), col='dodgerblue3', lwd=2)
points(chltot~Light, data=D.sum.df, col="mediumseagreen", pch=16, cex=0.7)
abline((lm(chltot~Light, data=D.sum.df)), col='mediumseagreen', lwd=2)
points(chltot~Light, data=D.win.df, col="orchid", pch=16, cex=0.7)
abline((lm(chltot~Light, data=D.win.df)), col='orange', lwd=2)
legend("topright", c("C-sum", "C-win", "D-sum", "D-win"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3","mediumseagreen", "orange"), cex=1, y.intersp = 0.3, x.intersp = 

plot(density(C.sum.df$chltot), col="tomato2", pch=16, cex=0.7,
     xlab="Light (DLI)", ylab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")),
     main="chl: Light and Season", ylim=c(0, 0.4), xlim=c(0,15), lwd=2)
lines(density(C.win.df$chltot), col="dodgerblue3", lwd=2)
lines(density(D.sum.df$chltot), col="orange", lwd=2)
lines(density(D.win.df$chltot), col="mediumseagreen", lwd=2)
legend("topright", c("C-sum", "C-win", "D-sum", "D-win"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3", "orange", "mediumseagreen"), cex=1, y.intersp = 0.3, x.intersp =


###### density plot: by season
plot(density(data.winter$chltot), ylim=c(0,0.3), xlim=c(0, 18), col="dodgerblue3", main="chl: Seasons",
     xlab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")))
lines(density(data.summer$chltot), col="tomato2")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.35


###### density plot: by Site
plot(density(F1.R46.df$chltot), ylim=c(0,0.3), xlim=c(0, 18), col="tomato2", main="chl: Sites",
     xlab=expression(paste("chlorophyll", ~(mu*g~cm^-2), sep="")), ylab="Density")
lines(density(R42.df$chltot), col="skyblue3")
lines(density(F8.R10.df$chltot), col="springgreen4")
lines(density(HIMB.df$chltot), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))
dev.copy(pdf, "figures/physiology/PanKB.chl.pdf", width=9, height=7)






##################
# Fig: chlorophyll/cell over season and depth
##################
plot(chlcell~newDepth, data=data.winter,col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)",
     ylab=expression(paste("pg chlorophyll cell"^-1, sep="")), main="chl/cell: Depth and Season",
     xlim=c(0,10), ylim=c(0,15))
abline((lm(chlcell~newDepth, data=data.winter)), col='dodgerblue3', lwd=2)
points(chlcell~newDepth, data=data.summer, col="tomato2", pch=16, cex=0.7)
abline((lm(chlcell~newDepth, data=data.summer)), col='tomato2', lwd=2)
```

```r
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(data.winter$chlcell), ylim=c(0,0.4), xlim=c(0, 15), col="dodgerblue3", main="chl/cell: Sea
lines(density(data.summer$chlcell), col="tomato2")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(F1.R46.df$chlcell), ylim=c(0,0.4), xlim=c(0,15), col="tomato2", main="chl/cell: Sites", xla
lines(density(R42.df$chlcell), col="skyblue3")
lines(density(F8.R10.df$chlcell), col="springgreen4")
lines(density(HIMB.df$chlcell), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/physiology/PanKB.chlcell.pdf", width=9, height=7)



##################
# Fig: symbionts over season and depth
##################

plot((zoox/10^6)~newDepth, data=data.winter,col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab=(expression(paste(~italic("Symbiodinium") ~(10^6~cells~cm^-2), sep=""))), xl
     main= "zoox: Depth and Season")
abline((lm((zoox/10^6)~newDepth, data=data.winter)), col='dodgerblue3', lwd=2)
points((zoox/10^6)~newDepth, data=data.summer, col="tomato2", pch=16, cex=0.7)
abline((lm((zoox/10^6)~newDepth, data=data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(data.summer$zoox/10^6), col="tomato2", main="zoox: Seasons",
     xlab=(expression(paste(~italic("Symbiodinium") ~(10^6~cells~cm^-2), sep=""))), xlim=c(0, 7))
lines(density(data.winter$zoox/10^6), col="dodgerblue3")
legend('topright', c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(F1.R46.df$zoox/10^6), col="tomato2", main="zoox: Sites",
     xlab=(expression(paste(~italic("Symbiodinium") ~(10^6~cells~cm^-2), sep=""))), xlim=c(0, 7))
lines(density(R42.df$zoox/10^6), col="skyblue3")
lines(density(F8.R10.df$zoox/10^6), col="springgreen4")
lines(density(HIMB.df$zoox/10^6), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/physiology/PanKB.zoox.pdf", width=9, height=7)
```

```r
##################
# Fig: biomass over season and depth
##################

plot(biomass~newDepth, data=data.winter,col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste("Total biomass", ~(mg~cm^-2), sep="")),
     xlim=c(0,10), ylim=c(5,60),
     main="biomass: Depth and Season")
abline((lm(biomass~newDepth, data=data.winter)), col='dodgerblue3', lwd=2)
points(biomass~newDepth, data=data.summer, col="tomato2", pch=16, cex=0.7)
abline((lm(biomass~newDepth, data=data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.08


###### density plot: by season
plot(density(data.winter$biomass), ylim=c(0,0.08), xlim=c(0, 70), col="dodgerblue3", main="biomass: Seas
lines(density(data.summer$biomass), col="tomato2")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), cex=1, y.intersp = 0.3, x.intersp = 0.4, bty="n", inset=c(-0.35


###### density plot: by Site
plot(density(F1.R46.df$biomass), ylim=c(0,0.1), xlim=c(0,70), col="tomato2", main="biomass: Sites",
     xlab=expression(paste("Total biomass", ~(mg~cm^-2), sep="")))
lines(density(R42.df$biomass), col="skyblue3")
lines(density(F8.R10.df$biomass), col="springgreen4")
lines(density(HIMB.df$biomass), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       y.intersp = 0.3, x.intersp = 0.4,
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/physiology/PanKB.biomass.pdf", width=9, height=7)
```

Isotopes

```r
### ISOTOPES ##
###############

##################
# Fig: d13C host over season and depth
##################

plot(host..d13C~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{13}, C[H], " (\u2030, V-PDB)")),
     xlim=c(0,10), ylim=c(-20,-10),
     main= "d13C host: Depth and Season")
abline(lm(host..d13C~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(host..d13C~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(host..d13C~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08
```

```r
###### density plot: by season
plot(density(na.omit(data.summer$host..d13C)), col="tomato2", main="d13C-host: Seasons",
     xlab=expression(paste(delta^{13}, C[H], " (\u2030, V-PDB)")), xlim=c(-20, -8))
lines(density(na.omit(data.winter$host..d13C)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$host..d13C)), col="tomato2", main="d13C-host: Sites",
     xlab=expression(paste(delta^{13}, C[H], " (\u2030, V-PDB)")), ylim=c(0,0.4), xlim=c(-20, -8))
lines(density(na.omit(R42.df$host..d13C)), col="skyblue3")
lines(density(na.omit(F8.R10.df$host..d13C)), col="springgreen4")
lines(density(na.omit(HIMB.df$host..d13C)), col="purple")
legend("topright" ,c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d13C-host.pdf", width=9, height=7, encod="MacRoman")



##################
# Fig: d13C symb over season and depth
##################

plot(symb..d13C~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{13}, C[S], " (\u2030, V-PDB)")),
     xlim=c(0,10), ylim=c(-20,-10),
     main= "d13C symb: Depth and Season")
abline(lm(symb..d13C~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(symb..d13C~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(symb..d13C~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$symb..d13C)), col="tomato2", main="d13C-symb: Seasons",
     xlab=expression(paste(delta^{13}, C[S], " (\u2030, V-PDB)")), xlim=c(-20, -8))
lines(density(na.omit(data.winter$symb..d13C)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$symb..d13C)), col="tomato2", main="d13C-symb: Sites",
     xlab=expression(paste(delta^{13}, C[S], " (\u2030, V-PDB)")), ylim=c(0,0.4), xlim=c(-20, -8))
lines(density(na.omit(R42.df$symb..d13C)), col="skyblue3")
lines(density(na.omit(F8.R10.df$symb..d13C)), col="springgreen4")
lines(density(na.omit(HIMB.df$symb..d13C)), col="purple")
legend("topright" ,c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d13C-symb.pdf", width=9, height=7, encod="MacRoman")
```

```
##################
# Fig: d13C skeleton over season and depth
##################

plot(d13C..skel~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{13}, C[Skel], " (\u2030, V-PDB)")),
     xlim=c(0,10), ylim=c(-6,2),
     main= "d13C skel: Depth and Season")
abline(lm(d13C..skel~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(d13C..skel~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(d13C..skel~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$d13C..skel)), col="tomato2", main="d13C-skel: Seasons",
     xlab=expression(paste(delta^{13}, C[Skel], " (\u2030, V-PDB)")), ylim=c(0, 0.5), xlim=c(-8, 6))
lines(density(na.omit(data.winter$d13C..skel)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$d13C..skel)), col="tomato2", main="d13C-skel: Sites",
     xlab=expression(paste(delta^{13}, C[Skel], " (\u2030, V-PDB)")), ylim=c(0,0.5), xlim=c(-8, 6))
lines(density(na.omit(R42.df$d13C..skel)), col="skyblue3")
lines(density(na.omit(F8.R10.df$d13C..skel)), col="springgreen4")
lines(density(na.omit(HIMB.df$d13C..skel)), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d13C-skel.pdf", width=9, height=7, encod="MacRoman")


##################
# Fig: d13C host-symb over season and depth
##################

plot(d13C..host.sym~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{13}, C[H-S], " (\u2030, V-PDB)")),
     xlim=c(0,10), ylim=c(-2.5,3),
     main= "d13C h-s: Depth and Season")
abline(lm(d13C..host.sym~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(d13C..host.sym~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(d13C..host.sym~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$d13C..host.sym)), col="tomato2", main="d13C h-s: Seasons",
     xlab=expression(paste(delta^{13}, C[H-S], " (\u2030, V-PDB)")), ylim=c(0,1.5), xlim=c(-3, 5))
lines(density(na.omit(data.winter$d13C..host.sym)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35
```

```
###### density plot: by Site
plot(density(na.omit(F1.R46.df$d13C..host.sym)), col="tomato2", main="d13C h-s: Sites",
     expression(paste(delta^{13}, C[H-S], " (\u2030, V-PDB)")), ylim=c(0,1.7), xlim=c(-3,5))
lines(density(na.omit(R42.df$d13C..host.sym)), col="skyblue3")
lines(density(na.omit(F8.R10.df$d13C..host.sym)), col="springgreen4")
lines(density(na.omit(HIMB.df$d13C..host.sym)), col="purple")
legend("topright",c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d13Ch-s.pdf", width=9, height=7, encod="MacRoman")




##################
# Fig: d15N host over season and depth
##################

plot(host..d15N~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{15}, N[H], " (\u2030, air)")), xlim=c(0,10), ylim
     main= "d15N host: Depth and Season")
abline(lm(host..d15N~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(host..d15N~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(host..d15N~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$host..d15N)), col="tomato2", main="d15N-host: Seasons",
     xlab=expression(paste(delta^{15}, N[H], " (\u2030, air)")), xlim=c(0, 12), ylim=c(0, 1))
lines(density(na.omit(data.winter$host..d15N)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$host..d15N)), col="tomato2", main="d15N-host: Sites", xlab=expression(pa
lines(density(na.omit(R42.df$host..d15N)), col="skyblue3")
lines(density(na.omit(F8.R10.df$host..d15N)), col="springgreen4")
lines(density(na.omit(HIMB.df$host..d15N)), col="purple")
legend("topright" ,c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d15N-host.pdf", width=9, height=7, encod="MacRoman")


##################
# Fig: d15N symb over season and depth
##################

plot(symb..d15N~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab =expression(paste(delta^{15}, N[S], " (\u2030, air)")),
     xlim=c(0,10), ylim=c(2,7),
     main= "d15N symb: Depth and Season")
```

```r
abline(lm(symb..d15N~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(symb..d15N~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(symb..d15N~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$symb..d15N)), col="tomato2", main="d15N-symb: Seasons",
     xlab= expression(paste(delta^{15}, N[S], " (\u2030, air)")), xlim=c(0, 9), ylim=c(0, 0.9))
lines(density(na.omit(data.winter$symb..d15N)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$symb..d15N)), col="tomato2", main="d15N-symb: Sites",
     xlab= expression(paste(delta^{15}, N[S], " (\u2030, air)")),  xlim=c(0, 9), ylim=c(0,1.8))
lines(density(na.omit(R42.df$symb..d15N)), col="skyblue3")
lines(density(na.omit(F8.R10.df$symb..d15N)), col="springgreen4")
lines(density(na.omit(HIMB.df$symb..d15N)), col="purple")
legend("topright" ,c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d15N-symb.pdf", width=9, height=7, encod="MacRoman")



##################
# Fig: d15N host.symb over season and depth
##################

plot(d15N..host.sym~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste(delta^{15}, N[H-S], " (\u2030, air)")),
     xlim=c(0,10), ylim=c(-1,2),
     main= "d15N h-s: Depth and Season")
abline(lm(d15N..host.sym~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(d15N..host.sym~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(d15N..host.sym~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$d15N..host.sym)), col="tomato2", main="d15N h-s: Seasons",
     xlab=expression(paste(delta^{15}, N[H-S], " (\u2030, air)")), xlim=c(-1, 3), ylim=c(0,2))
lines(density(na.omit(data.winter$d15N..host.sym)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.3, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$d15N..host.sym)), col="tomato2", main="d15N h-s: Sites", xlab=expression
lines(density(na.omit(R42.df$d15N..host.sym)), col="skyblue3")
lines(density(na.omit(F8.R10.df$d15N..host.sym)), col="springgreen4")
lines(density(na.omit(HIMB.df$d15N..host.sym)), col="purple")
legend("topright" ,c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
```

```
      col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.d15Nh-s.pdf", width=9, height=7, encod="MacRoman")



##################
# Fig: C.N host season and depth
##################
plot(host..C.N~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste("C:N"[H])),
     xlim=c(0,10), ylim=c(5,10),
     main= "C:N-host Depth and Season")
abline(lm(host..C.N~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(host..C.N~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(host..C.N~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
plot(density(na.omit(data.summer$host..C.N)), col="tomato2", main="C:N-host Depth and Season",
     xlab=expression(paste("C:N"[H])), ylim=c(0, 1), xlim=c(4, 10))
lines(density(na.omit(data.winter$host..C.N)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$host..C.N)), col="tomato2", main="C:N-host Depth and Season",
     xlab=expression(paste("C:N"[H])), ylim=c(0,1.5), xlim=c(4, 10))
lines(density(na.omit(R42.df$host..C.N)), col="skyblue3")
lines(density(na.omit(F8.R10.df$host..C.N)), col="springgreen4")
lines(density(na.omit(HIMB.df$host..C.N)), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.C.Nhost.pdf", width=9, height=7, encod="MacRoman")



##################
# Fig: C.N symb season and depth
##################
plot(symb..C.N~newDepth, data=na.omit(data.winter),col="dodgerblue3", pch=16, cex=0.7,
     xlab="Depth (m)", ylab = expression(paste("C:N"[S])),
     xlim=c(0,10), ylim=c(5,14),
     main= "C:N-symb Depth and Season")
abline(lm(symb..C.N~newDepth, data=na.omit(data.winter)), col='dodgerblue3', lwd=2)
points(symb..C.N~newDepth, data=na.omit(data.summer), col="tomato2", pch=16, cex=0.7)
abline(lm(symb..C.N~newDepth, data=na.omit(data.summer)), col='tomato2', lwd=2)
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.08

###### density plot: by season
```

```r
plot(density(na.omit(data.summer$symb..C.N)), col="tomato2", main="C:N-symb Depth and Season",
     xlab=expression(paste("C:N"[S])), ylim=c(0, 0.8), xlim=c(5, 15))
lines(density(na.omit(data.winter$symb..C.N)), col="dodgerblue3")
legend("topright", c("summer", "winter"), lty=c(1,1), lwd=c(2,2),
       col=c("tomato2", "dodgerblue3"), y.intersp = 0.3, x.intersp = 0.4, cex=1, bty="n", inset=c(-0.35

###### density plot: by Site
plot(density(na.omit(F1.R46.df$symb..C.N)), col="tomato2", main="C:N-symb Depth and Season",
     xlab=expression(paste("C:N"[S])), ylim=c(0,0.8), xlim=c(5, 15))
lines(density(na.omit(R42.df$symb..C.N)), col="skyblue3")
lines(density(na.omit(F8.R10.df$symb..C.N)), col="springgreen4")
lines(density(na.omit(HIMB.df$symb..C.N)), col="purple")
legend("topright", c("Fringe-Reef 46", "Patch-Reef 42", "Fringe-Reef 10", "HIMB"), lty=c(1,1), lwd=c(2,2
       col=c("sienna1", "skyblue3", "springgreen4", "purple"), cex=0.8, bty='n', inset=c(-0.5, -0.1))

dev.copy(pdf, "figures/isotope/PanKB.C.Nsym.pdf", width=9, height=7, encod="MacRoman")
```